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U. S. DEPARTMENT OF AGRICULTURE.

ANNUAL REPORT

OF THE

OFFICE OF EXPERIMENT STATIONS

FOR THE YEAR ENDED JUNE 30,

1908.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

JOINT RESOLUTION Providing for printing annually the Report of the Director of the Office of Experiment Stations, Department of Agriculture.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That there be printed eight thousand copies of the Report of the Director of the Office of Experiment Stations, prepared under the supervision of the Secretary of Agriculture, on the work and expenditures of that Office and of the agricultural experiment stations established in the several States and Territories under the act of Congress of March second, eighteen hundred and eighty-seven, for nineteen hundred and three, of which one thousand copies shall be for the use of the Senate, two thousand copies for the use of the House of Representatives, and five thousand copies for the use of the Department of Agriculture; and that annually hereafter a similar report shall be prepared and printed, the edition to be the same as for the report herein provided.

Approved, April 27, 1904.

THE OFFICE OF EXPERIMENT STATIONS.

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E. W. Allen, Ph. D., Assistant Director and Editor of Experiment Station Record.
W. H. Beal, A. B., M. E., Chief of Editorial Division.
Mrs. C. E. Johnston, Chief Clerk
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T. K. Burrows, B. A., Editorial assistant.
William Henry, Indexing and proof reading.

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W. H. Evans, Ph. D., Chief.

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C. C. Georgeson, M. S., Special agent in charge, Sitka.
G. W. Gasser, B. S., Assistant at Rampart.
R. W. De Armond, Assistant at Sitka.
Chas. W. H. Heideman, Assistant at Copper Center.
M. D. Snodgrass, Assistant at Kodiak.
J. W. Neal, Assistant at Fairbanks.

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E. V. Wilcox, Ph. D., Special agent in charge, Honolulu.
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D. T. Fullaway, A. B., Assistant entomologist.
J. E. Higgins, B. A., M. S. A., Horticulturist.
C. J. Hunn, B. S. A., Assistant horticulturist.
W. P. Kelley, M. S., Chemist.
Alice R. Thompson, B. S., Assistant chemist.
F. G. Krauss, in charge of rice investigations.
Q. Q. Bradford, Assistant in rubber investigations.

PORTO RICO EXPERIMENT STATION.

D. W. May, M. Agr., Special agent in charge, Mayaguez.
W. V. Tower, B. S., Entomologist.
M. J. Iorns, Ph. D., Horticulturist.
J. W. van Leenhoff, Coffee expert.
P. L. Gile, A. B., Chemist.
E. G. Ritzman, Assistant animal husbandman.
G. L. Fawcett, Assistant plant pathologist.

Agricultural Education.

D. J. Crosby, M. S., Specialist in agricultural education.
John Hamilton, B. S., M. S. A., Farmers' institute specialist.

Nutrition Investigations.

C. F. Langworthy, Ph. D., Expert in nutrition investigations.
R. D. Milner, Ph. B., Assistant in nutrition investigations.

Irrigation Investigations.

Samuel Fortier, D. Sc., Chief of irrigation investigations.
R. P. Teele, M. A., Editorial assistant and acting chief in absence of the chief.

Irrigation engineers and irrigation managers.—A. P. Stover, in charge of work in Oregon; C. E. Tait, in charge of work in Imperial Valley and Arizona; F. W. Roeding, in charge of work in California; S. O. Jayne, in charge of work in Washington; W. W. McLaughlin, in charge of work in Utah; P. E. Fuller, in charge of power investigations; O. W. Bryant, in charge of work in Colorado and Wyoming; W. L. Rockwell, in charge of work in Texas; Don H. Bark, in charge of work in Kansas.

Assistant irrigation engineers.—V. M. Cone, H. I. Moore, F. L. Bixby.

Expert mechanician.—E. J. Hoff.

Irrigation farmers.—John H. Gordon, R. G. Hemphill, W. H. Lauck, R. E. Mahoney, John Krall, Jr.

COLLABORATORS.

O. V. P. Stout, in charge of work in Nebraska, University of Nebraska.
B. P. Fleming, in charge of work in New Mexico, New Mexico Agricultural College.
G. H. True, in charge of work in Nevada, University of Nevada.
Elias Nelson, in charge of work in Idaho, Idaho Agricultural College.
W. B. Gregory, in charge of rice irrigation in Louisiana and Texas, Tulane University, New Orleans.

Drainage Investigations.

C. G. Elliott, C. E., Chief of drainage investigations.

Supervising drainage engineers.—J. O. Wright, A. E. Morgan, W. J. McEathron.

Drainage engineers.—C. F. Brown, L. L. Hidinger, Lawrence Brett, H. A. Kipp, S. H. McCrory.

Assistant drainage engineers.—D. G. Miller, Omer Fairley, W. W. Weir, F. F. Shafer, O. G. Baxter, H. M. Lynde, G. A. Griffin, G. R. Boyd.

Office engineer.—R. D. Marsden.

LETTER OF TRANSMITTAL.

Office of Experiment Stations,
Washington, D. C., April 28, 1909.

Sir: I have the honor to transmit herewith the annual report of the Office of Experiment Stations, the publication of which is authorized by joint resolution of the Fifty-eighth Congress, second session. This includes a report on the work and expenditures of the agricultural experiment stations established under the act of Congress of March 2, 1887, for the fiscal year ended June 30, 1908, in compliance with the following provision of the act making appropriations for this Department for the said fiscal year:

> The Secretary of Agriculture shall prescribe the form of the annual financial statement required by section three of the said act of March second, eighteen hundred and eighty-seven, shall ascertain whether the expenditures under the appropriation hereby made are in accordance with the provisions of said act, and shall make report thereon to Congress.

There is also a report for the same year on the receipts and expenditures and work of the stations under the act of Congress of March 16, 1906, in accordance with section 5 of that act.

Very respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

ANNUAL REPORT OF THE OFFICE OF EXPERIMENT STATIONS, JUNE 30, 1908.

WORK OF THE OFFICE OF EXPERIMENT STATIONS.

The work of the Office of Experiment Stations included during 1908, as it has for several years past, the supervision of the expenditures of Federal funds by the agricultural experiment stations throughout the United States; conferences and correspondence with station officers regarding the management, equipment, and work of the stations; the collection and dissemination of information regarding the progress of agricultural education and research throughout the world by means of technical and popular bulletins; the management of the agricultural experiment stations in Alaska, Hawaii, Porto Rico, and Guam; special investigations on the nutrition of man and on irrigation and drainage, conducted largely in cooperation with experiment stations, educational institutions, and other agencies in different States and Territories; and the promotion of the interests of the agricultural colleges and schools and farmers' institutes throughout the United States.

RELATIONS WITH THE AGRICULTURAL EXPERIMENT STATIONS.

The policy of this Office in the administration of the Adams Act has met with the cordial approval of the station officers and workers generally and their hearty cooperation in efforts to put the new work under this act on a high plane has been very gratifying. Naturally, many questions of detail have arisen regarding the proposed projects. In settling these questions the Office has sought to give the stations information and advice based on its broad study of the work of such institutions at home and abroad, and on the general interests of our agriculture as viewed from the standpoint of an agency familiar with agricultural conditions throughout the United States. Its advice and assistance in the framing and inaugurating of new projects have been freely sought. In this way the Office has been brought into closer touch with the stations than ever before and its relations with them have been most cordial and satisfactory.

It is evident that the Adams Act is to have a profound effect in raising the level of station work and in bringing into the service of

agriculture in this country a much larger force of thoroughly equipped scientists. The plans advanced for the improvement of our agriculture through scientific efforts are being subjected to closer scrutiny and analysis than ever before and there is keener competition in the search for ultimate facts and conclusions.

In order that the scientific work of our stations may be properly recorded in permanent form, and thus be brought to the attention of students and investigators throughout the world, there is great need of a specific medium for the publication of such work. It is believed that this need can be fully met only by the assembling of the scientific reports of the stations in a journal or series of monographs published through a central agency. This journal should have competent editorial supervision, suitable illustrations, and durable paper. The present miscellaneous publication of station work is satisfactory neither to the farmer nor the scientist. Much of the scientific work of our stations is now practically buried in a mass of popular material. The present plan is especially disadvantageous to our weaker stations. If the scientific work were published separately in the way suggested, it would be possible to present the practical results in much more effective form for the farmer's reading. It is very much to be hoped that the earnest discussion of this matter which is now going on will speedily result in a satisfactory plan for the publication of the scientific work of our stations.

The increase of the financial resources of the stations through recent Federal and State legislation and the consequent broadening of their operations has had important results as regards the use of the Hatch fund. The Adams Act makes no provision for administration or printing, and many State appropriations are strictly limited to special lines of investigation. This has made it seem desirable or necessary to use the Hatch fund in increasing measure for expenses of administration, printing, and miscellaneous general purposes. This is believed to be an unfortunate tendency, and if pushed to an extreme easily results in a practical diversion of that fund from the purposes for which it was primarily intended. This danger has further been increased by the rapid development of the extension movement in our agricultural colleges. This calls for the issuance of numerous popular publications and the conducting of a vast miscellaneous correspondence. Where special funds are not available for the extension work the tendency has been to lay this burden on the stations. This is wholly wrong, for the extension departments of the colleges, when properly organized and equipped, should rather relieve the stations of the miscellaneous correspondence and compilation which do not belong to research institutions. This Office has, therefore, felt obliged to call attention strongly during the past year to the obligation resting upon the States to use the Hatch fund

primarily for experimental work, and the consequent desirability of increased State appropriations for station administration, printing, and miscellaneous purposes. This call has already been met by a number of State legislatures, and there is good reason to believe that when the situation is fully understood a proper adjustment of appropriations and expenditures will be made in all the States.

The increased Federal appropriation for the more scientific work of the stations has been met by the States with a more liberal policy than ever before in the granting of funds for the establishment of substations, demonstration fields, cooperative experiments, and special investigations of great local importance. In this way the stations are more fully able to meet the practical needs of farmers, and the American system of experiment stations not only has a deeper foundation but is also enlarging its borders and more fully covering the field of practical agriculture.

INSULAR EXPERIMENT STATIONS.

While no very radical changes have been made in the work of these stations during the year, some of the lines of work which had been previously reported upon were completed or supplanted for a time by others which were believed to be of more immediate importance. While the present needs of the people for whose benefit the stations were established receive as much attention as possible, in planning the work the scientific trend of investigations has not been sacrificed for immediate results. The policy of conducting investigations which will result in agricultural diversification has been continued, and the stations are now becoming recognized as important adjuncts to the permanent development of Alaska, Hawaii, and Porto Rico.

In Alaska the pioneer work is continuing and will have to be carried on along the same lines for some years to come, and in connection with the investigations some experimental work on plant and animal breeding is being conducted. The herd of Galloway cattle begun at Kenai in 1906 has increased until there are now 60 head in all. Acting upon what seemed the best interests, the cattle were removed from Kenai to Kodiak in the fall of 1907, and the animal-breeding station will be maintained on that island. The horticultural and agricultural work at the different stations in Alaska has been carried on along the lines previously reported, and for some crops it is possible for the stations to make definite recommendations as to the varieties adapted to their vicinities.

At the Hawaii and Porto Rico stations attempts are being made to introduce new crops, and the people are beginning to cooperate with the stations and to seek advice regarding their problems. In Hawaii especial attention is being paid to the growing of rice, cotton, rubber,

pineapples, and other tropical and subtropical fruits, to insect pests, and to the shipping of fruits. In Porto Rico the lines of work are somewhat similar, and in both regions the stations are endeavoring by their investigations, cooperative experiments, and demonstration work to improve the agricultural conditions of their territories.

Congress, in providing for this Department for the fiscal year 1909, appropriated $5,000 for the establishment and maintenance of an agricultural experiment station on the island of Guam. A preliminary survey has been made of the situation, and a station established and work begun looking toward the improvement of the agriculture of the island. For the most part the work will of necessity be in the nature of demonstrations for some time to come, and the principal lines will be crop introduction and improvement and the introduction and breeding of animals. Some of the work will have to be of a very elementary nature in order to suit it to the people, but it is believed that some scientific investigations on adaptation and improvement can be carried on at the same time.

As in the past, the various bureaus of this Department have been generous in cooperating with the insular stations, and in this connection it is desired to make proper acknowledgment to each for its assistance.

The business connected with these stations has, as hitherto, been in charge of Dr. Walter H. Evans, as Chief of the Division of Insular Stations.

The character and scope of the work carried on at the stations are briefly summarized below.

ALASKA STATIONS.

During the season of 1908 the weather on the whole was favorable to agricultural pursuits both in the coast region and in the interior. In both regions the spring was late and cloudy, and as the soil did not dry out promptly, seeding was late, but by the middle of summer the weather was more favorable and the results secured were correspondingly satisfactory. The rainfall along the coast was less than the average, and on this account large yields were obtained of most of the crops under investigation. In the interior of Alaska the conditions were quite similar, the rainfall being a little less than the average, and there was a correspondingly greater amount of sunshine, which hastened the growth and maturity of the crops.

Satisfactory progress was made at all the stations during the past year, and no changes were made in the lines of work. At Sitka, horticultural investigations continue to be given first consideration, and plant breeding to secure better and hardier fruits is being carried on. Some of the hybrids resulting from the crossing of the wild salmon berry and the cultivated Cuthbert raspberry and from the

crosses between the native wild strawberry and a cultivated variety have fruited, and the selection of the desirable types has been begun. There are now under observation about 1,000 plants of the raspberry-salmon berry crosses and 2,000 of the hybrid strawberry plants. In connection with the strawberry investigations it is being learned that there are probably two species of strawberries indigenous to Alaska, one occurring along the coast region, the other in the interior. Experiments are being conducted with both forms. The work at the Sitka Station with other fruits has been continued, and several hundred apple, plum, and cherry trees, together with a considerable number of currants, gooseberries, and other small fruits, are being propagated. A few cherries have been matured, but the other trees are too young for fruit bearing. A number of varieties have been found that do not winterkill, and when older it is hoped that some of them may bear fruit. Currants and gooseberries do exceedingly well at the Sitka Station. As rapidly as stock of the different fruits accumulates it is distributed to settlers in different parts of the country for comparative testing. During the past season a large number of pollinations were made of the wild crab, using pollen of different early varieties of apples received from the States. A considerable number of fruits set, and it was hoped that from them there might be obtained some Alaskan varieties of promise. All were lost, however, through Indian collectors of crab apples for jelly making, as they did not recognize or respect the bagged clusters. The variety tests of potatoes that have been conducted for three years have shown the more desirable varieties for Alaskan conditions, and the station can now recommend about a dozen varieties whose quality and yield are satisfactory. The station at Sitka has been able to take up experiments with chicken raising, and the work thus far has been quite successful. An incubator has been secured that works with reasonable satisfaction. As soon as possible more chicken houses and pens are to be built, and several promising breeds of fowls are to be introduced to extend this experiment.

At the Copper Center and Rampart stations cereal growing receives most attention, and through hybridizing and continual selection early-maturing varieties of oats, barley, wheat, and rye are being sought. At the Rampart Station out of 67 varieties of cereals of all kinds only 2 failed to produce viable seeds during 1908 and 56 ripened their entire crop. Samples of grain secured through the Bureau of Plant Industry of this Department from Siberia, northern Russia, and at high elevations in the Himalaya regions have all grown well, and from them some excellent varieties are expected to be developed. Of all cereals the earliest ripening heads are saved and planted in breeding plats. This has been continued for several

years, and already there can be noticed an increasing earliness of the crop from the seed that has been so selected. Attention is given at the stations to mutations and volunteer cereals, and as a result a variety of wheat and one of barley have been established that seem very promising. A white sport from the Finnish Black oats has been obtained that will be propagated to determine its value. At present it is highly thought of by those who have seen it. At the Copper Center Station Superintendent Heideman crossed some varieties of barley, and he now has under observation the hybrid progeny. Some of these are giving indications of being of great value.

In addition to the work with cereals attention is given at each station to the cultivation of potatoes, hardy vegetables, and forage plants. At the Copper Center Station a considerable number of varieties of native grasses and leguminous plants have been brought together in an attempt to secure forage plants for that region. About 50 species have been collected, and they are being grown under cultivation to determine their adaptability for domestication.

During 1908 work was actually begun at the station near Fairbanks, reserved by Executive order, March 22, 1906. About 10 acres of land were cleared and planted to grain and potatoes. Owing to the difficulties of obtaining labor and the preliminary work required, seeding was not done until the end of May. As has been found elsewhere, the first crop in Alaska is a poor one, owing to the newness and unevenness of the soil, yet at the Fairbanks Station cereals were ripened and potatoes and other vegetables produced for use and for seeding purposes in 1909. In addition to the cultivation of the crops 45 acres of land were cleared and prepared for cropping, a barn was built, and other necessary buildings erected. The station at Fairbanks is getting a fairly good equipment together and, through the courtesy of the United States Geological Survey, it secured seven horses from field parties that had closed their work.

In order to develop the Fairbanks Station more rapidly, it is planned to close the Copper Center Station temporarily and transfer the equipment and experiments to Fairbanks. It has been found that early frosts are prevalent at Copper Center, doubtless due to the proximity of the high snowclad mountains, and there is also a deficiency of rainfall. In 1908 the lack of rain greatly retarded the germination and early growth of spring-sown crops. There was but one-half inch of rainfall from April 1 to July 11 and all the crops suffered severely. The station will not be abandoned, and investigations may be resumed whenever the Copper River Valley becomes more accessible and its development begins anew.

The live-stock breeding work has been consolidated by the removal of animals and equipment from Kenai to Kodiak, which is a much more accessible locality. The transfer of the stock was effected in the

autumn of 1907. The station has at present on Kodiak Island about 60 head of pure-bred Galloway cattle, and they have proved hardy and well adapted to their surroundings. The reservation of 160 acres near the town site of Kodiak was found too small for the purpose of a stock farm, and 150 acres of land adjoining has been temporarily inclosed and added to the above reservation. Even with this addition, the area has proved too small for the desired purpose, and a tract in the valley at the head of Calsinsky Bay, about 15 miles from Kodiak, has been selected as a permanent reservation for station purposes. The herd has been divided and the more promising dairy animals kept near the village of Kodiak, while the rest of the herd has been removed to Calsinsky Bay. At present the principal energies at this station are devoted to the erection of buildings and fences. There have been erected on the reservation at Kodiak a dairy and hay barn and a small dairy building, and at Calsinsky Bay a hay barn, cattle shed, silo, and a cottage for the herdsman. In addition to the daily work of caring for the herd and the transfer of the greater portion of it to Calsinsky Bay, the superintendent was able to put up 70 tons of hay and 65 tons of silage. The silo erected is of the stave form, 16 feet high and 20 feet in diameter, with a capacity of 100 tons. This can be readily increased, as the silo was so constructed that by raising the roof additional sections can be added to it. The cattle went through the winter of 1907–8 in a fairly good condition, receiving a little feed when severe storms were prevailing. The only losses to the herd were three cows that died from impaction of the third stomach, through the eating of large quantities of dead dry grass in their attempt to get at the early sprouting grass in May. The experience has shown that it will be necessary to feed cattle through the month of May, and it is believed with this precaution that no further losses will be reported.

The letters from settlers who are cooperating with the station in various parts of the country continue to be a source of gratification to those connected with the Alaska investigations. They show a lively interest in the stations' work and are aiding in spreading information regarding agriculture and horticulture in that country.

HAWAII STATION.

The former special agent, Mr. Jared G. Smith, who had been in charge of the Hawaii Station since its establishment, resigned at the end of the fiscal year to engage in private business, and he was succeeded by Dr. E. V. Wilcox, who had been connected with the editorial staff of this Office for about nine years. Several other changes were made, with the result that the station now has a fully equipped staff, capable of giving attention to almost any line of agricultural inquiry, except in plant pathology.

With the increased revenues of the station it has been possible to put the grounds, buildings, and equipment in a better condition than heretofore, but additional quarters for offices and laboratories are needed.

Considerable extension is reported in the orchard plantings, about 200 trees having been added during the year. The banana plantation, which now consists of about forty varieties, has been moved from near the office to a more sheltered location, where the conditions for banana growing seem to be more favorable.

As in the past, the special agent and other members of the station staff have visited various localities on the different islands, practically all the important districts being visited in supervising cooperative work or in investigating new problems.

The principal horticultural investigations during the year were in connection with shipping fresh fruit, including pineapples, avocados, papaias, and bananas. The demonstration of the possibility of shipping pineapples and avocados as far as Chicago was followed by commercial shipments to various inland cities. The great increase in the acreage of pineapples has called attention to the necessity of further developing the market for fresh fruit, and the results thus far obtained are quite encouraging. Much attention has been given to cover crops for orchards. The ones thus far used are chiefly cowpeas, pigeon peas, and jack beans. Of these the cowpea makes the quickest growth, but it is quite susceptible to insect attack. The pigeon pea requires longer to reach maturity, while the jack bean makes a slower growth, but it is a good cover crop and is exceptionally free from insects. Experiments with the rough lemon have proved that it is an excellent stock for use in establishing citrus orchards, and extensive budding tests with citrus fruits are in progress. Considerable attention has been given to the propagation of mangoes, and experiments have shown that 80 per cent of the buds of the Alphonse mango formed successful unions. With other varieties the results were not so satisfactory. Inarching appears to be the surest means of propagating fine varieties of mangoes, but this method is rather more expensive than budding. In experiments in transplanting mango trees two or three years old it was found that they would quickly start into growth when transplanted. In shipping experiments with young mango trees it was found that a large percentage will be lost in transit unless the trees are selected with reference to firm wood and a dormant terminal bud. Studies are being made of the flowering period of the mango, which seems to vary from year to year, and data are being collected with reference to the time of principal flowering. More than 300 species of economic plants were added to the horticultural collection during the year. There is a constantly increasing call for plants and cuttings for distribution in

different parts of the islands, and the station has complied with these requests so far as its facilities would allow.

In the entomological investigations particular attention has been given to a study of injurious insects affecting live stock, and in co-operation with Dr. V. A. Nörgaard, territorial veterinarian, the station entomologist prepared a report giving a complete survey and a detailed account of the sheep maggot fly and of the hornfly of cattle. An attempt is being made to introduce the natural parasites of the hornfly to supplant direct and indirect insecticidal measures for the control of that pest. The entomologist has devoted considerable time to the investigation of apicultural problems and to the encouragement of bee raising. The total crop of honey for 1908 was estimated at about 1,000 tons. The available locations for apiaries have been largely taken up, but there is still room for considerable extension. A survey has been made of the honey plants of the islands, and a number of new honey plants, many of which are also useful for other purposes, have been introduced. Investigations on the life histories and methods of control of insects affecting rice, citrus fruits, melons, cotton, tobacco, stored products, pineapples, and other fruits are in progress. The station has for the time closed its work in the investigation of mosquitoes, the important facts concerning their life history and suppression having been determined and published. A revised list has been prepared of the injurious insects of Hawaii and also additions to the entomological library relating to Hawaiian entomology.

In the investigations with various agricultural crops, studies with rice have been given a prominent part. The general interest in these investigations is increasing from year to year, and considerable progress has been noted both in the breeding of varieties and in the use of fertilizers. A variety originally from Ceylon has proved to be an exceptionally heavy yielder and is especially adapted as an export crop for consumption by Chinese on the mainland. This variety is best used as a fall crop. A variety of Egyptian rice has given excellent returns in dry-land culture. The yield of grain is satisfactory, and this variety promises well as a hay crop on account of its smooth glumes and large yield. During the year an elaborate series of fertilizer experiments was carried on in continuation of those begun in 1907. It has now been shown that when fertilizers are applied to the rice after the crop is two-thirds grown the first crop receives the least benefit and the succeeding crop the greatest on account of the residual effect of the fertilizers. On the other hand, if the fertilizer is applied before planting, the first crop of the season takes up nearly all the fertilizer, while the second crop receives little or no benefit. Pot experiments have shown that there is no residual effect of nitrate of soda upon the second crop, even though the application be made at a

late stage of growth of the first crop. The greatest residual effects upon the second crop have been produced by the use of sulphate of ammonia and fish guano. Experiments have demonstrated that rices which mature slowly receive the most benefit from fertilizers which become available slowly, such as sulphate of ammonia. In direct fertilizer experiments a comparison was made between sulphate of ammonia, lime nitrogen, and nitrate of soda, and it was found that sulphate of ammonia doubled the yield as compared with unfertilized rice and gave much better results than either of the other two sources of nitrogen. In dry-land culture of rice, muriate of potash produced striking results. The experimental results with rice have attracted much attention, and the station has been called upon to formulate plans for the fertilizing and management of large rice plantations.

On account of the lack of natural hay crops in the islands, experiments were carried on with upland rice and salt-marsh rice as hay crops, which seem to indicate that a large portion of the $250,000 annually paid for imported hays may profitably be devoted to the production of a home crop, either from upland rice, which can be produced with a quantity of water amounting to 2½ inches per week during the growing season, or from salt-marsh rice.

The experiments with matting sedges and rushes which have been carried on for the past two years have shown the possibility of producing large yields of these two matting materials. The quality seems to be very good, but the greatest difficulty is one of profitable handling. The Chinese matting sedge requires splitting, and this so far has greatly increased the cost of production.

The station has been experimenting with cotton for several years, particular attention being given to the Sea Island and Caravonica cottons. The yields of these cottons are high and the fiber of some strains is exceptionally good as regards length, strength, and luster. The varieties thus far have been grown as perennials in the islands, and experiments are being carried on to determine the effect of pruning on the shape of the trees, maturity of the bolls, etc. An expert opinion of some of the samples of cotton placed them quite high regarding the lint, a sample of Sea Island being rated as superior to the crop of 1908 produced either in Florida or Georgia.

Experiments have been carried on with other miscellaneous crops, such as soy beans for green manuring and as a source of human food, particularly in connection with the manufacture of the Japanese product, "Miso." The growing of peanuts has been begun in several localities, and a number of varieties were tested on the trial grounds during the season. It was shown that wheat of the variety which produces the straw used in the manufacture of Leghorn hats could be successfully grown in Hawaii, and the possibility of developing this industry to a limited extent seems assured. These miscellaneous

crops were tested not only for their intrinsic value as crops, but also for their suitability for rotation with rice and other crops that are grown in Hawaii.

The principal work of the chemical department during the year was of an analytical nature and was concerned chiefly with the determination of the composition of paddy, rice straw, and rice grain. Several varieties of imported Japan rice and Japan rice grown in Hawaii were analyzed to determine the nutritive value of the imported as compared with the Japan rice grown in Hawaii. The results of the analyses show that Japan rice grown in Hawaii is slightly more nutritious than that imported from Japan. Analyses were also made of a number of fodders and feeding stuffs. In connection with the pineapple investigations, analyses were made of soils, which showed as a rule a low lime content and in some cases a deficiency in potash and available phosphoric acid. Other studies have shown a high percentage of manganese in some of the soils, and where this was present in a large amount it had a detrimental effect upon the pineapple plants.

In continuation of the experiments with rubber, plantings have been made of seeds of *Hevea brasiliensis*. It was found that they germinated and grew best when the shell had been removed and the seeds planted in clean sand. In the tapping experiments the herringbone system of tapping Ceara rubber trees gave favorable results. In some experiments on the island of Kauai it was found difficult sometimes to coagulate the latex, but this was finally accomplished by the addition of hydrogen peroxid and sulphuric acid. The use of a water bag containing water to which a small amount of ammonia was added was found to increase the relative amount of first-grade rubber as compared with scrap rubber. The tapping of yearling trees was found to be of value as indicating undesirable ones that could be cut out of the plantation.

The work of the station as a whole has progressed very favorably during the year, and its cooperation and assistance are being sought more and more.

PORTO RICO STATION.

The equipment and staff of this station were added to and strengthened during the year. Dr. Oscar Loew, for a number of years with this Department and later with the College of Agriculture, Tokyo University, Japan, was connected with the station for a few months during the year as physiologist. During that time he made some important researches upon the fermentation of cacao and coffee, certain alkali conditions of some of the Porto Rican soils, and the fermentation of tobacco as practiced in Porto Rico. In connection with the studies on cacao fermentation he found that the chief object of

fermentation is to shrink the slime tissue or pulp attached to the seed, allowing the remnants to be washed away or dried upon the seed, forming an irregular brown filament. This greatly facilitates the drying of the seed. The fermentation has an indirect influence, as the temperature kills the cells, thus liberating oxidizing enzyms, which cause the formation of the brown color through the oxidation of the tannin of the seed. This brown coloration is further increased by the drying and roasting processes. The flavor of the cacao beans is changed by the partial oxidation during the fermentation and also by roasting. The enzyms and also the final roasting play a considerable part in the development of the aroma. A close analogy was found between the fermentation of cacao and that of coffee. The rôle of the alcoholic and acetic fermentation of coffee is the separation of the slimy layer from the parchment envelope of the seed. This is not dissolved, but merely loosened, and can be readily washed from the parchment coffee. In the studies on Porto Rican soils it was found that in some regions there is a decided tendency to alkalinity, while elsewhere the soils are quite acid. In general, the cane and tobacco soils of Porto Rico show sufficient quantities of potash and phosphoric acid, nitrogen being the element most needed. While there are deficiencies in the soils in different localities, they are such as can readily be corrected.

In connection with field crops the station has been devoting especial attention to sugar cane. Sugar is now the greatest export of the island, and the area devoted to cane is rapidly being extended. There are two distinct areas in Porto Rico in which cane is cultivated—a wet region on the north side of the island and a dry one, where irrigation is necessary, on the south side. The requirements of these two regions are being studied as rapidly as possible, in order that better methods of cultivation may be adopted and the yield of sugar increased. A large number of varieties of cane have been secured and the best have been selected and are being distributed. Some of the seedling canes obtained from the British stations in the West Indies have proved richer in sucrose than the varieties usually grown in Porto Rico, some of them yielding more than 20 per cent sucrose in the juice. The station has also taken up the production of new seedling canes and has a number under trial that appear quite promising. Crop rotation and soil renovation by means of leguminous plants are receiving attention, and it is believed that sowing cowpeas, which ripen in about sixty days, between the rows of cane will prove practicable and beneficial. Experiments in distance of planting cane have shown that close planting is the most profitable method. In connection with sugar production, the utilization of the low-grade molasses as a source of denatured alcohol is being investigated. Experiments have

shown that denatured alcohol can be made the cheapest fuel available for cooking purposes. Its use is rapidly being extended, and it is believed that it may displace charcoal, the only other available fuel. Some attention is being given to fiber plants, and the station is assisting in the introduction and dissemination of Sea Island cotton, sisal, fiber palms, etc.

The experiments with live stock have been continued and considerably extended, and the indications are that all classes of live stock, including poultry, may be introduced from the States with comparative safety. Practically no horses are now used for working in the fields, as they are generally too small for that purpose. The native mules are also below the size for profitable work in the fields, and attempts should be made to breed up larger animals. Experiments at the station have shown that horses and mules can be maintained at a much lower cost than in the States. In the introduction of cattle, attention will have to be given to the possibility of tick infection. The native animals and the cross-bred ones are characterized by a very short, smooth coat, and it seems that this is favorable for the removal of ticks. Where cattle are imported, care will have to be given them until they become acclimated. No difficulty has been experienced with the introduction of any other animals. The station is continuing to breed pigs and poultry for sale at moderate prices among the planters. The demand for these products has exceeded the supply, and great interest is being taken by the people of Porto Rico in the improvement of their live stock. A dairy is being constructed and a silo has been built. Another silo will be erected shortly and experiments will be made in ensiling the coarse pasture grasses and cane tops, which are now largely wasted.

The horticulturist is giving especial attention to the improvement of tropical fruits and to the best methods of cultivation and marketing. Through the Bureau of Plant Industry of this Department and otherwise extensive introductions of varieties of tropical fruits are being made, and the horticultural collections of the station are becoming a very important part of the equipment. The station has under cultivation the leading varieties of oranges, grape fruit, pineapples, etc., and is distributing them as rapidly as they can be propagated. Numerous seedling pineapples have been produced, some of which give promise of being valuable. Considerable attention is being paid to the introduction of improved mangoes, and trees, representing about 20 of the best varieties, have been secured from India and from the French and British West Indies. With these more than 200 inarches have been made. Investigations have been carried on for a considerable time on pineapple culture and marketing, and a bulletin has been issued treating of this subject. New plantings have been made of aguacates, cacao, rubber, guavas, and miscella-

neous trees and fruits. A test is being made of about 30 species of Eucalyptus for reforesting the denuded areas of the island. Some attention is being given to grape culture, and by severe pruning three varieties have been forced into bearing, and it is hoped that in a few years grape culture will be an established industry. The horticultural plant breeding at the station includes muskmelons, cucumbers, peanuts, cowpeas, etc. A successful method of propagating breadfruit trees by root cuttings has been worked out which is more certain than the method usually employed. This is done by clearing away the soil and exposing the larger roots, after which they are severed about 2 feet from the tree, the ends being left exposed. In a short time new plants will start from the cut ends, and when these become well rooted they may be cut free and transplanted. By this means a number of new plants have been obtained from a particularly good seedless breadfruit tree.

The entomologist has devoted much time to a study of the insects affecting citrus fruits, pineapples, cotton, etc., and means for their control. Life history studies have been made of the purple scale (*Lepidosaphes beckii*), showing that these insects reach maturity in thirty-five to forty days for the males and fifty-six to sixty-five days for the females. Observations indicate that the young appear at all seasons throughout the year. A number of other scale insects have been studied and the value of miscible oils tried for their control. In many instances the miscible oils were found superior to kerosene or crude-oil emulsions. For the white scale, miscible oils have been used with exceptionally good results. Experiments have shown the desirability of fumigating pineapple slips with hydrocyanic-acid gas for mealy bugs. Some precautions are to be observed. It is not advisable to fumigate wet plants, as the moisture which collects between the leaves forms an envelope that prevents the gas from passing down to where the insects are situated. When the plants are taken from the fumigating box they should be kept in the shade for about twenty-four hours. If placed immediately in the sun, the outer leaves become discolored and dry up.

Some successful introductions of Italian bees have been made, and the production of honey will be given attention, especially in connection with coffee growing, as bees are said to aid very materially in the pollination of the coffee flowers.

The chemical work for the past year was of a miscellaneous character, consisting largely of analytical work, although some research has been carried on in reference to the catalase content of soils. A considerable portion of the chemist's time during the year was taken up with the installation of the chemical laboratory, but in addition he completed more than 120 analyses of soils, guanos, fertilizers, fruits, sugar cane, etc. Several unproductive soils were studied, and

the application of lime and gypsum to some of them was found to be followed with excellent results. Large deposits of bat guano occur in different parts of Porto Rico, and as these are being more or less sought for fertilizers the chemist has made a study of a number of them and has found thus far that most of them have little value as nitrogenous or potash fertilizers, but they contain sufficient phosphoric acid to make them valuable as a source of phosphate.

The investigations at the coffee substation have been continued on the lines previously described. Owing to dry weather in April, 1907, followed by an abnormally heavy rainfall in May and hail in September, the coffee crop was greatly reduced. The value of bananas as provisional wind-breaks has been thoroughly tested, and their use is definitely recommended for young plantations. A number of the introduced varieties of coffee are coming into bearing and, in addition to 35 acres of native coffee under cultivation, the experiments are being extended with the best varieties of Java and other high-priced coffees. In the experiments in renovating an old coffee plantation, the fourth year's report shows that the net cost per acre for improvement for the four years has been $91.56. This includes the cost of pruning, thinning, cultivation, fertilizers, etc. The trees were heavily loaded at the time of the preparation of this report, and the value of pruning, fertilizing, and cultivation should begin to show in the next few crops.

The pathologist, who has been connected with the station for only a very short time, has made a preliminary survey of some of the diseases of economic plants, and reports that comparatively little disease was found among the citrus fruits. The most conspicuous disease of the pineapple is apparently due to organisms which gain entrance to the leaves through punctures made by insects. At the point of attack white spots are developed which gradually enlarge until the tissue is destroyed and a white, bleached appearance taken on. There is also a decay of the root system that seems to be associated with heavy soils, which is being studied. Some attention is also being given the diseases of sugar cane, but thus far this crop seems to be free from serious losses due to that cause.

There is evidence of the introduction of new agricultural industries in Porto Rico, but it seems probable that certain districts will, for some time to come, be devoted largely to a single crop. In these regions the station is carrying on cooperative experiments on a centrally located plantation, the planters paying all the expense of the experiments, while the members of the station staff plan and carry out the work. In this way the planters of a neighborhood have an object lesson, and the work of the station is brought directly to the farmers. In connection with these cooperative experiments work is always carried on in crop diversification in order to secure the introduction of other crops than sugar and coffee.

GUAM STATION.

Congress, in making appropriations for this Department for 1909, included the sum of $5,000 for the establishment and maintenance of an agricultural experiment station on the island of Guam. In order that definite information be secured regarding the agricultural needs of the island and the conditions under which experimental work must be conducted, the Chief of the Division of Insular Stations visited Guam during the summer of 1908 to make a study of the problems of organization and lines of investigation to be adopted.

Guam, which was acquired from Spain as a cable and naval station, is the largest of the Ladrone or Marianne group of islands, and is situated about 3,300 miles west and south of Honolulu and 1,500 miles east of Manila. The island is about 30 miles long and 8 or 9 miles wide, and contains about 250 square miles. It is of volcanic origin, fringed with coral reefs, and while there are a number of mountain peaks none of them exceeds 1,400 feet in height and most of them are less than 1,000 feet in elevation. The northern part of the island is an elevated plateau, while the southern half contains the more important mountains. The only river of any size is the Agaña River, which rises a couple of miles inland and, after traversing the famous "Cienaga," or swamp, runs parallel to the coast through the principal town and finally empties into the sea. In the northern part of the island streams are said to be few and small, the rainfall disappearing through the porous soil. There are a number of small streams in the southern part of the island.

The rainfall is said to be about 100 inches per annum. As reported by Safford,[a] the total precipitation for 1902 was 116.46 inches. This was distributed throughout the year, although 84.28 inches fell in the rainy season, from July to November, inclusive. The temperature of Guam is very equable, the annual maximum for 1902 being 82° F. and the minimum 78°, with 90° as the absolute maximum and 66° the absolute minimum.

The soils of the island vary in different regions from a fine coral sand along the beaches, light reddish loam underlaid with coral limestone on the mesas, to deep black adobe-like clay along the rivers and in the deeper valleys. The mesa soils are said to be especially adapted to growing tobacco, sweet potatoes, and corn, although under the native methods of cultivation they soon become exhausted. The strand soils are eminently suited to coconuts, which have been grown along the western coast from time immemorial. The heavy black soils are very rich and produce excellent crops of maize, rice, and other products, but during the dry seasons they

[a] Useful Plants of Guam, U. S. Nat. Mus., Contrib. Nat. Herbarium, 9 (1905), p. 42.

are liable to bake and crack. Many of these tracts of black soil are so situated as to be readily irrigated, and they should prove very productive. In some of the higher parts of the island there are stretches of land more or less covered with a growth of rank coarse grass that is worthless for pasture except for a short period after it has been burned over. Elsewhere the forest covers nearly all the land, even the low mountains.

Various estimates have been made as to the proportion of the island adapted to agriculture, but in the absence of surveys and a thorough study of the subject they are of little value. Formerly there was considerable agriculture practiced, many of the people having small ranches, often at a considerable distance from the villages where they make their homes. There appears to be a distinct decline in agriculture, and it is said that this has been going on for several years. The principal agricultural products are maize, rice, garden vegetables, such as eggplants, peppers, onions, beans, squashes, melons, yams, and sweet potatoes, and fruits, such as bananas, oranges, limes, mangoes, breadfruit, and coconuts.

The principal crop of the island appears to be the coconut, which flourishes nearly everywhere. The trees are said to begin bearing in five or six years, and every bearing tree is estimated to yield a revenue of $1 per year. The trees bear almost indefinitely, although very old trees are less fruitful than the younger ones. The fruit is used green, is fed to pigs, dogs, and chickens, and when ripe is used as food as well as for the manufacture of copra. The leaves are extensively used in thatching houses and to some extent in supplying the sides of the houses. Other parts of the plant enter largely into the life of the people, and the planting of coconuts is being considerably extended.

Coffee of excellent flavor is grown in the higher portion of the island, especially in the interior, but it is not extensively produced anywhere. Cacao has been cultivated to some extent, and attempts have been made to introduce most of the tropical crops from time to time. Numerous small areas of tobacco were seen about the houses, and in the form of smoking tobacco it is used very extensively by the people. Nearly every householder grows a few plants, which vary greatly in size and appearance, no effort apparently having been made to improve the crop. It is cut and hung in the shade to cure, but is never fermented. When smoked it has a rank odor, and is said to be very strong. Formerly considerable sugar cane was grown and recently an attempt was made to revive the industry, but little came of it and the planting of cane has almost ceased.

Of the important foodstuffs not enough are raised to supply the local requirements, and rice and flour are imported in considerable quantities. Formerly considerable rice was grown in Guam,

but its cultivation seems to have almost entirely ceased. The importation of rice is largely in the hands of the Japanese, and at times advantage has been taken of the scarcity of rice to advance the price enormously. The only export, and practically the only crop that enters into trade, is copra, the dried flesh of the coconut. As the Japanese are the principal importers of rice, they are also the sole buyers of copra, and the prices paid are often below the market value of the material. In July, 1908, the price received for copra in Guam was $3\frac{1}{2}$ to 4 cents Mexican per pound, while the average price in Manila was 6 or 7 cents.

Among forage plants, dependence is largely placed on the leaves of such plants as the breadfruit, banana, and cononut. As mentioned above, a coarse grass abounds in the savannas, but it makes very poor pasture. Some Bermuda grass was seen growing in the lowlands, and maize is used to some extent as forage, but the main dependence seems to be placed on breadfruit leaves, etc. No hay seems to be made and there was but little pasture seen. The animals of the natives were for the most part in very poor flesh, indicating insufficient feeding. Of domestic animals there were horses, cattle, carabao, pigs, and chickens. All the animals were undersized and apparently of inferior breeds, probably due to long-continued inbreeding and a lack of sufficient feeding. All the stock kept at the naval station had been imported and it was being fed exclusively on forage shipped from the Pacific coast States.

Some three or four years ago an attempt was made to carry on some experimental work in the large garden attached to the governor's residence. Considerable work was done with vegetables and the possibility of their production and improvement was shown. In a small way a few trees of improved varieties of tropical fruits were introduced from Hawaii and elsewhere, and their growth has been remarkable. These experiments, after progressing for a few years, were discontinued, but they have shown the possibility of securing results in a comparatively short time.

In connection with the establishment of an experiment station in Guam, one of the first and most important problems to be considered was the selection of a tract of land suitable for station purposes. Probably three-fourths of the people of the island live in Agaña or along the road between Agaña and Piti, the principal port of Guam. After a conference with the governor and a number of the leading citizens, it was decided that the station should be located where it would be readily accessible and seen by the greatest number of people. There was practically no available land in the immediate vicinity of Agaña and no public land that was at all accessible. After considerable investigation a tract of about 30 acres was leased, with an option on its purchase. This tract is situated about 4 miles

from Agaña on the road between that town and Piti. On the west side of the tract is the Maso River, from which it will be possible to irrigate if necessary. Although the tract is not large, it contains nearly every type of soil found on the island except the strand, and it will be possible to carry on experiments on what appear to be the most important lines. Arrangements have been made for the fencing of the tract and the erection of some necessary buildings, and experimental work will be begun as soon as the pioneering is finished.

The lines of work which are to be taken up at once are those that appear to promise immediate results. These will include the introduction and breeding of crops of various kinds, forage plant production, improved methods of tillage, soil conservation and improvement, introduction of live stock, and animal breeding. Before much can be done in the introduction of improved animals, attention will have to be paid to securing ample supplies of forage, and seeds of a large number of tropical forage plants have been sent to Guam and it is hoped that some will prove adaptable to the conditions existing there. When pasture and forage are assured, horses, cattle, swine, and probably poultry, will be sent to the station with a view to breeding better animals than those now in the island. Some attention is now being paid to bee keeping, a few colonies having been secured through the Hawaii Agricultural Experiment Station in 1907. These have multiplied rapidly, and there is a great demand for honey and for colonies of bees. This lot of bees was the first successfully introduced, and their rapid multiplication and abundant stores of honey indicate that bee raising can be readily made a successful industry.

Some attention will soon have to be given to plant pests. A mealy bug, *Pseudococcus cocotis*, which it is claimed was introduced from the Philippines, is proving a serious pest of the coconut trees, especially the young trees. These insects occur in great numbers, usually within the leaf sheath and in the folds of the young leaves, and through their abundance sometimes cause the death of the young trees. Doubtless other pests will be found when the work has progressed and a more complete survey has been made of the situation.

Arrangements were made whereby Mr. H. L. V. Costenoble was temporarily placed in charge of the new station. Mr. Costenoble has been in Guam for a number of years and had charge of the experimental work that was carried on in the governor's garden, as mentioned above. He is thoroughly acquainted with the local conditions and, speaking the native dialect, he will doubtless be able to interest the people in the station's work better than one less experienced. Experts in different lines of investigation will be added to the staff as required, but for the present the work in relation to the people will have to be mainly in the nature of demonstration experiments.

The condition of the people of Guam is such that active measures should be taken to restore and develop agriculture. The people are naturally agricultural and they should be encouraged to again till their farms and, by means of demonstration experiments, aided in improving their animals, crops, and cultural methods.

NUTRITION INVESTIGATIONS.

In accordance with the terms of the appropriation made by Congress, the respiration calorimeter, with accessory material, which was the property of the Department of Agriculture, was moved from Middletown, Conn., to Washington, D. C., and stored.

The respiration calorimeter and the apparatus used in connection with it are costly and valuable. In addition, the Office is in possession of reports of a large number of nutrition investigations, popular summaries, and similar data. The collection of this material was time-consuming and expensive, and much of it is of decided interest and value. Such of the material as was filed in Middletown was also brought to Washington.

On the completion of the new Department of Agriculture building, adequate and suitable quarters were set aside for the installation of the respiration calorimeter, and its reconstruction is now progressing. It has not been found necessary or desirable to modify the general lines on which the calorimeter was originally built, but in the reconstruction many improvements in detail have been introduced which make for simplicity, economy, and convenience of operation and for accuracy in the results obtained. The work has gone forward rapidly and the apparatus will be completed and ready for operation before the close of the fiscal year 1908–9.

Plans have been made for utilizing the apparatus in studies of the nutritive value of agricultural products used as human food along lines in harmony with the general work of the Department. The enterprise involves cooperation with other bureaus and the supplementing, not the duplicating, of their work where it concerns the utilization of dairy products, cereal products, and other animal and vegetable foodstuffs produced by our farms, ranches, and gardens.

It is proposed to study the relative ease of digestion of cheese made and cured in different ways, comparing the different varieties with each other and with meat, bread, and other standard food products, a line of work of the utmost importance, in view of experiments already completed which have demonstrated the thoroughness of digestion and high nutritive value of cheese in quantity as an economical article of diet.

It is also proposed to study the relative value of butter, lard, beef fat, olive oil, and other edible or culinary fats as sources of energy in

the body, a matter on which data are much needed in considering the problems which at the present time are of especial interest to the Department of Agriculture.

Studies already made and in part reported have shown the value as an integral part of the diet of fruits and of preserves, jams, jellies, dried and evaporated fruits, etc., and of nuts and nut products, a matter which is of decided importance to all who are interested in the production of fruits and nuts and the manufacture of food products from them.

The additional studies of such materials which are needed involve the use of the respiration calorimeter for the measurement of factors which are at present imperfectly understood.

The information which has been secured and published in the nutrition investigations regarding the digestibility and nutritive value of meats of different kinds and cuts is of value to the producers of farm animals used as food and to those who are interested in the handling and marketing of meat and meat products, and to the consumer who wishes to select such foods wisely and to prepare them in appetizing ways and use them in reasonable proportion in combination with other foods. To round out this work other investigations involving the use of the respiration calorimeter are needed.

What has been said of work with fruits, nuts, meat, and meat products is equally true of wheat, corn, and other cereals and the products made from them. The results already obtained in connection with the nutrition investigations have furnished accurate and useful data regarding the nutritive value of these foods, but there are many other important questions which remain unanswered.

It should also be said that in the study of the relative energy expenditure required of the body for performing different kinds of farm and household work and in studies of the relation of physical work of this and other sorts to food supply no other means of experimenting offers as much hope of ultimate success as the respiration calorimeter.

The work of the Department in nutrition investigations and kindred lines has a vital relation to the work of our agricultural colleges. In response to a widespread demand among farmers and other people, these colleges are conducting courses in home economics in which instruction regarding the nutritive value of different foods and ways of handling and cooking them is an important feature. These colleges have for years looked to the Department for aid in this line and are now doing so more than ever. The agricultural colleges have been stimulated by a recent act of Congress to organize courses for teachers along this line, as well as other branches of agricultural and mechanical arts. Secondary and primary schools all over the country

are taking up this work and the demand for teachers and for information outruns the supply.

Recognizing the importance of the nutrition investigations of the Department in this connection, students, teachers, investigators, and individuals interested in the problems are turning to the Department in increasing numbers for information and suggestions. This is one phase of the great movement for the improvement of life in both country and city and other education directly relating to home interests and the vocations of the people and the dissemination of information along such lines. It has long been understood that work of this character has been undertaken by the Department, and the demand for information continues to increase.

In accordance with the usual policy of the Department the results of the nutrition investigations have been published as technical bulletins in limited editions, while the general deductions of popular interest which have been drawn from the investigations have been summarized in Farmers' Bulletins and other popular publications designed for general circulation.

At the present time 57 technical bulletins and 37 Farmers' Bulletins and other popular summaries have been published as a result of the nutrition investigations, as well as numerous reports of progress, and similar articles. The nutrition publications issued during the past year have included two technical bulletins and a Farmers' Bulletin, a Yearbook article, two special articles, general summaries for the Annual Report of the Office of Experiment Stations, and similar reports.

The subjects treated in these publications are as follows: Course in cereal foods and their preparation, for movable schools of agriculture (prepared in cooperation with the Division of Farmers' Institutes), and Digestibility of starch of different sorts as affected by cooking, both of which are technical bulletins; Nuts and their uses as food; Food and diet in the United States; The nutrition investigations of the Office of Experiment Stations and their results; and The relation of nutrition investigations to questions of home management.

In addition to the above, two technical bulletins and two Farmers' Bulletins have been prepared for publication, while several other bulletins are approaching completion.

As a part of the regular work in nutrition, abstracts of the current literature on the general subjects of physiological chemistry and nutrition have been prepared for the Experiment Station Record, as well as popular summaries, particularly of work carried on at the American experiment stations, for publication in the series of Farmers' Bulletins entitled "Experiment Station Work."

As has been the case for many years, many requests for information along nutrition lines have been received, alike from Members of

Congress, teachers, institution managers, home makers, and others, and in so far as practicable the data requested have been supplied. The work connected with nutrition investigations, as heretofore, has been in charge of Dr. C. F. Langworthy.

IRRIGATION INVESTIGATIONS.

The season of 1908 completed ten years' work in irrigation investigations by this Office. The work of those ten years and something of the changes which have taken place during that time are discussed at some length in another part of this report (pp. 355–405), and it seems best to review here the work of the decade in a more general way. Dr. Samuel Fortier is Chief of Irrigation Investigations.

Beginning shortly after 1880 and extending to the panic of 1893 there was a period of great activity in canal building. Attracted by the great rise in land values where water was made available for irrigation, large amounts of capital were put into irrigation works which were extended far beyond the limits of existing settlement. For various reasons the expected settlement did not take place, the settlers who came were largely without means, many of the large canals built were unused, and very few of them were used to a sufficient extent to bring a fair return on the capital invested in them. Many canals were abandoned, others were sold for anything that could be gotten out of them, while a few were held by the original investors in the hope that some time they would pay out. Under such circumstances few canals were well managed, making them unsatisfactory to the water user as well as to the investors. The fact that many canals which were completed were only partially used, while others were uncompleted, and many schemes for which rights were claimed had never gone farther than the surveys, led to endless confusion as to the rights to water, casting doubt upon the efficiency of irrigation laws which might have proven satisfactory under other conditions. The attempt to settle such large areas put many of the farms in the hands of men wholly unfamiliar with irrigation practice, resulting in excessive and improper use of water and consequent loss of crops and injury to lands.

It was during this era of confusion as to water laws, of financial loss to investors and farmers, and of depreciation of canal property and of irrigated lands that Congress provided for the work of irrigation investigations carried on by this Office. The act making appropriations for this Department, passed in 1898, contained an item of $10,000 "for the purpose of collecting from agricultural colleges, agricultural experiment stations, and other sources * * * valuable information and data on the subject of irrigation, and publishing the same in bulletin form." This charter was so broad in its terms that the

Office was practically free to take up whatever line of inquiry promised most in relieving the conditions then prevailing. After conference with officials of a number of western experiment stations and the State engineers of several States it was decided that the greatest service would be rendered by working along two lines: (1) The collection and publication of information regarding the laws and institutions of the irrigated region in their relation to agriculture; and (2) the publication of available information regarding the use of water in irrigation and the encouragement of further investigations along this line by the experiment stations. In other words, the institutional and agricultural phases of irrigation were taken up rather than the engineering phase, except as that was incidental to the others. This action was indorsed by Congress at its next session, when it provided for the investigation of "the laws and institutions relating to irrigation" and "the use of irrigation waters, with especial suggestions of better methods for the utilization of irrigation waters than those in common use." While the language of subsequent appropriation acts has changed slightly, this general description of the work undertaken stands to the present time.

In accordance with the terms of the original law the first work undertaken was the collection and publication of available information along the two general lines mentioned, it being the belief of those responsible for the work that a thorough knowledge of existing conditions was a necessary preliminary to investigations having for their object the improvement of those conditions. The first two bulletins published contained abstracts of the laws for acquiring titles to water from the Missouri River and its tributaries and discussions of the conditions which had arisen under these laws. The third bulletin was along the same lines, showing the complications arising on an interstate stream, sections of which are under the jurisdiction of different States and consequently subject to different systems of laws, as well as to different sets of administrative officials. Later, special studies of irrigation laws and their operations were made in California, Utah, Montana, and Wyoming.

These studies of irrigation laws revealed the fact that under the laws of most of the arid States there was great confusion as to water rights. Certain general principles regarding the nature of water rights were universally recognized, but the administrative machinery for making these principles effective was usually lacking. The principles of priority of rights and the dependence of rights upon beneficial use were acknowledged everywhere, but in two States only was there any provision for determining and recording all rights in such a way that it was possible to find out what rights were in existence. There was a general lack of provision for the public protection of rights and for the orderly acquirement of new rights. The reports

published called attention to the evils of this lack of order, and pointed out the necessity for providing for the defining of all existing rights, for such public supervision of the acquirement of new rights as would define them as they were acquired, and for public officials to police streams and distribute their water to those holding rights. Very largely as a result of this work, laws based on the general lines advocated in our reports have been adopted in Idaho, Nevada, Utah, North Dakota, South Dakota, Oklahoma, and New Mexico, and movements for the adoption of similar systems have been started in the remaining arid States and Territories.

Concurrent with these bulletins was a series dealing with the agricultural situation, the first one being a general description of irrigation practice in the Rocky Mountain States, another one dealing especially with conditions in Wyoming, and a third containing the results of measurements of the quantities of water used under typical canals in each of the arid States and Territories except two, where satisfactory arrangements could not be made at that time.

The bulk of the work for three or four years was of this same general character. Measurements of the quantities of water used in all of the arid States and Territories were continued. With the season of 1901 the determination of the quantities of water used in general practice ceased to be a leading feature of the work, because it was believed that measurements extending through three years and covering practically the entire arid region gave a sufficient knowledge of general practice. Since that time the work in that line has dealt rather with the possibilities of improving general practice and the best means of reaching these possibilities.

The measurements made showed wide variations in the quantities of water used under apparently similar conditions, indicating extremely wasteful practice on the part of some water users. They showed also enormous losses of water in transit between the sources of supply and the places of use and also in use. Since the ultimate extent of the irrigated area in the arid region is limited by the water supply rather than by the available land, here seemed to be the field in which the greatest good could be accomplished, as any decrease in the quantities of water used and any losses checked meant an increase in the available water supply and a consequent increase in the irrigable area. It is our belief that by economical use and the saving of losses the areas at present irrigated can be served with one-half the water now diverted for their irrigation, making this water available for extending the irrigated areas.

To accomplish this it is necessary to stop or check the losses from canals so far as possible, and we have made experiments to determine the efficiency and cost of different types of linings, and in sections where freezing prevents lining experiments have been made to find

other methods of checking losses. It is necessary to check evaporation after the water has been applied to the land, and we are carrying on a series of experiments to find out what methods of cultivation will do this most effectively. It is also necessary to check waste, and here we enter the field of irrigation institutions and make studies of the effects of water laws, canal organizations, and ditch regulations upon the quantities of water used. The results of these studies will be of increasing value as the demand for water becomes greater and the supply is more nearly exhausted.

Just at present, however, the most pressing need is not for economy in water but for economy in the time and money of those who are settling on the lands being brought under ditch as a result of the great activity in ditch building which has existed for the past few years. It is estimated that there is an area of 5,000,000 acres under ditch and ready for settlement at the present time. The settlers to reclaim this land must come very largely from sections where irrigation is not practiced, and they will be unfamiliar with irrigation practice. Their own success and, consequently, that of those who have advanced the money for the building of the irrigation works will depend very largely upon their learning how to prepare their land and irrigate their crops without loss of time and money in experimenting. Earlier irrigation works were much less expensive than those now being built, and yet these have been very generally financial failures. With the much more expensive works now being built the burden of the settler and, consequently, his chances for failure are greatly increased.

For the sake of both the settler and the investor there is being prepared a series of bulletins giving practical directions as to how to remove native vegetation, level land, build farm ditches, and apply water to crops. In order to inform proposed settlers as to the opportunities for securing homes on irrigated lands, and as to the conditions to be met, a second series of reports giving such information for the several States and Territories of the arid region is being published. It is hoped that by supplying reliable information as to the climate, soil, crops, canal systems, and conditions of purchase of land and water this Office can be of great assistance in securing settlers for the lands being brought under irrigation. The failure of earlier canal companies was due to inability to secure settlers before interest and maintenance charges had destroyed all chances for profit. The series of reports just referred to should be of great value to investors in irrigation works, both public and private, by assisting them in securing settlers promptly.

However, our work is primarily for the benefit of farmers rather than investors, and the greatest need of the settlers is for practical directions which will enable them to properly prepare their land and

irrigate their crops so as to secure the best returns for their labor, and such directions are being furnished to them by means of the practical bulletins referred to, by personal advice given by our field men, and by demonstrations carried on in cooperation with State stations and individuals.

The present situation in the arid region resembles in very many ways the active period of irrigation development preceding the period of depression described on page 35. Vast sums are being invested in irrigation works, bringing under ditch great areas of fertile lands. The financial success of these projects demands that the lands be settled and placed under cultivation quickly, and begin to produce paying crops at once. Maintenance charges on an unused canal will in a few years exceed the first cost, while interest on the investment soon equals the cost. When such great areas are being brought under ditch at one time there is grave danger that some, at least, of the projects will not secure settlers until they have met the fate of their predecessors of twenty years ago. Every effort should be made to avert this disaster, and our work has been along that line.

The similarity between the present agricultural situation and that of twenty years ago does not end with the arid region. The semiarid section of the Great Plains was very largely put under cultivation then as it is to-day. It is claimed by many that advance in cultural methods and the growth of drought-resisting crops make the present settlement unlike the former wave, but this is only partially true. Doubtless some of the settlers will adopt the most modern methods and drought-resisting crops, but many will try to get along with the methods to which they have been accustomed and are doomed to failure. Even at its best, dry farming can not produce crops every year. There will be seasons when without irrigation no crop can be raised, and only settlers with capital can stand crop losses. Here, as in the arid region, there is grave danger of a repetition of former failures. To guard against this so far as possible, this Office has established three stations in the semiarid region to determine the possibilities of securing small water supplies for the irrigation of a small part of each landholding to insure sufficient crops to carry settlers over the dry years, and enabling them in the better years to grow fruits and vegetables which can not be grown without irrigation.

A few years before the beginning of the irrigation work of this Office, the development of the rice industry of Louisiana and Texas on a large scale began. The rapid development of this industry brought up many questions, both legal and agricultural, and almost from the beginning of our work we have been studying the problems of the rice growers. The reports published up to this time deal principally with pumping for rice irrigation, but studies of irrigation practice, both in

the States mentioned and in Arkansas, have been made and a report giving the information regarding the irrigation of rice needed by a beginner in rice growing has been prepared.

One of the earlier bulletins of this Office dealt with irrigation in Connecticut and New Jersey. For many years irrigation has been practiced by market gardeners in these and other Eastern States, and in some sections meadows have been watered. These facts led to the undertaking of experiments to determine the value of irrigation in the humid parts of this country. These were carried on in New Jersey, Wisconsin, Missouri, and Iowa, the general conclusion reached being that under present conditions irrigation will not pay with general farm crops, but that it does pay with truck crops and perhaps with grass crops. These experiments have been discontinued except in Iowa, where grass crops are being irrigated with sewage water. The experiments have not been continued long enough to give definite results. With the development of winter truck growing in the South Atlantic States a new field for work has been opened up. Winter is the dry season in that section, making irrigation necessary to insure success in truck growing. This industry is developing with great rapidity, and here, as in the arid West, there is a great call for practical directions as to how to prepare land for irrigation and apply water to crops. An expert has been assigned to this field and is devoting his entire time to studying methods and advising beginners regarding their work. Experiments are being conducted at many points in cooperation with local parties.

Throughout the United States there are many places where the water supply is secured by pumping, and there is a constant demand for information regarding the kinds of pumps and engines used, the cost of fuel, etc. To secure the information demanded, investigations and tests of pumping plants in use for supplying water for irrigation have been carried on throughout the ten years of the Office work. Most of this work and the reports giving the results are technical, and the reports contain probably the largest amount of reliable data on pumps in actual operation in existence. These data need to be summarized and digested, and this work is to be taken up.

Throughout the ten years in which irrigation investigations have been carried on by the Office the attempt has been made to keep in touch with agriculture and undertake the work which seemed most needed by those practicing irrigation. Before beginning the work the lines to be taken up were decided upon in conference with leading western men. The same cordial relations with local parties have been maintained, and every effort will be put forth to maintain them. In that way the needs of irrigated agriculture can be most surely ascertained, and the results of the work made most readily available.

DRAINAGE INVESTIGATIONS.

The art of draining land for agricultural use is not expressed by a fixed formula which may be successfully applied to wet lands everywhere, but rather by one which lends itself conveniently to modifications which are required by the physical conditions of the land and the system of agriculture to which it is adapted. The great variety of inquiries which come to the Office from landowners in widely separated parts of the country emphasizes this statement. Questions similar to the following indicate the character of the information most frequently requested:

What is the best and most efficient method of reclaiming the bottom lands which are herein described? What will it cost? What will levees, drainage ditches, and pumping plants cost? Can you prepare plans for this work? Will the soil on my farm respond to underdrains; if so, how should they be placed and what effect may be expected? How deep should drains be made on the lands of which a description follows? Can you make plans for draining a territory of 50,000 acres situated in my county? I have a wet field on my irrigated farm; how can it be made dry enough to produce as good crops as it did when first irrigated? What kind of law should we have that will permit us to carry out drainage in our county where the lands of several owners will be benefited?

Much information upon the subjects covered by these questions is given by correspondence alone. In numerous cases an engineer visits the locality from which the request comes and frequently, after a brief inspection and study of the conditions, may be able to give the needed advice. In other cases a survey made in greater or less detail, together with an examination of the soil and of the surrounding watershed, is necessary before reliable and intelligent recommendations can be given. Requests come from engineers who have charge of drainage works, for information of a more technical character which they require in perfecting the plans for the work which they have in charge. Frequently consultation with some member of the drainage staff is requested upon the plans for particular projects. This involves a careful study of special features of the problems to be considered, and frequently a field examination in company with the engineers and commissioners who are charged with the responsibilities of the work.

The lack of special and definite information is greatly felt by all who are called upon to undertake the planning of drainage works. Such investigations relate to the amount of rainfall common to the locations for which drainage systems are contemplated; the relation of this rainfall to the size of ditches and drains required; the freeness with which water percolates through soils of various kinds

under different climatic conditions; the behavior of ditches in different kinds of land with respect to sedimentation and stability of the earth through which they are made; the distance apart and depth at which drains of various kinds should be placed; and the effects which may be expected from the construction of work performed in accordance with the described plans. Questions of a different character arise where work is executed under the provision of State drainage laws. Important among these is the manner of making assessments for the cost of works, appraising the damages, determining the proper limits of a drainage district, and the general scheme of apportioning costs and of conducting the engineering part of the work as provided for in the law under which the work is done.

The larger part of the work of the Office consists in complying with requests from individuals, communities, and organized drainage districts for assistance and advice and special surveys required in the initiation of drainage improvements. This involves the collection of a large amount of data on the ground, in advance of the preparation of detail plans. When requests for such work are filed with the Office a preliminary examination and report by a supervising engineer is first made, in order to determine the magnitude and character of the project, the attitude of the people toward the proposition, and, in general, its feasibility as far as may be determined by one who is experienced in making such investigations. This may be followed by a complete survey, made in cooperation with local interests, by a field party detailed for the work. A careful study of the entire situation is made in connection with the data secured, and maps, profiles, and working plans are prepared which, after approval by the office engineers, are transmitted to local authorities for their use.

The preparation of drainage plans requires not only the careful collection of facts and data which pertain directly to the lands under consideration, but also skill and judgment in the use of the information secured. It is the plan of this Office to take up all of the details that enter into these problems, especially in localities where so little drainage has been done that examples of adequate construction are not already available as precedents, or where there is a lack of competent engineers to make the required surveys and formulate plans adapted to the work. By reason of the great impulse that has been given to the reclamation of land by drainage during the last few years, it is beyond the resources of the Office to comply with all of the requests for this kind of assistance. It is therefore necessary to select projects with no little care, consideration being given to the degree of interest shown by the landowners concerned, their readiness to cooperate in the investigation, and later to proceed with the execution of the plans, provided they are such as can be confidently recommended by the Office. It should be especially noted, also, that

the improvement of lands already occupied and under cultivation is considered equally or more important than the reclamation of swamp lands.

A clearer understanding of the general work of the Office in drainage investigations, which are under the direct supervision of Mr. C. G. Elliott, will be obtained if the following classification is observed: (1) Improvement of farm lands which are already under cultivation. (2) The reclamation of level swamp lands which, in their natural condition, have no agricultural value. (3) The protection from overflow of farm lands whose fertility is known. (4) The drainage of irrigated lands which, through seepage and over-irrigation, have been greatly injured or made wholly unproductive. (5) Special investigations made to collect technical data pertaining to drainage, such as the amount of run-off from lands which are artificially drained as compared with those whose drainage is accomplished by natural streams; the success or failure in various parts of the country of efforts to drain lands of a peculiar physical structure, such as mucks, turfs, and impervious clays; cost data upon all classes of structures required in draining land, particularly in the construction and operation of pumping plants; and maintenance and cost of levees under different conditions of land and streams. (6) Assistance given in consultation with commissioners and engineers who have charge of large drainage works already organized; attendance upon public meetings for the discussion of drainage topics and the promotion of interest in the reclamation and improvement of wet lands suitable for agriculture.

The following is a brief description of a part of the work accomplished by the Office under the respective classes:

IMPROVEMENT OF FARM LANDS.

About 9 miles of drain tile were laid on the Minnesota Northwest Experiment Farm, at Crookston, under the supervision of John T. Stewart, of this Office. The drains were laid at different distances apart and at different depths in order to test, in an experimental way, the effectiveness of underdrains in soils of the Red River Valley, which are nearly level and known to be somewhat impervious to the percolation of water and freeze to a depth of 6 feet in winter. The crops upon the land had been greatly injured by surplus water during the five years previous. Arrangements have been made to measure and record the position of the ground water during the entire season, and also to measure the amount of flow from the entire system. Cement draintile were included in this experiment, to determine the relative merits of cement and clay pipes in such land. The cost of the different parts of the construction of this system was carefully noted.

The protection and drainage of a 2,500-acre farm in the Neosho Valley of Kansas, belonging to R. O. Deming, by means of a complete levee system, with a sluice gate for the discharge of interior drainage water, has been completed. Under the direction of this Office a system of experimental tile drains, constructed upon this farm in 1905, has proved efficient. This is the first tract of land in that valley to be protected by levees and furnished with a thorough system of interior underdrainage.

A system of thorough tile drainage was installed near Albany, in Linn County, Oreg., under the supervision of A. P. Stover, as an experiment to determine the value of underdrainage in restoring to production the worn-out wheat lands in the Willamette Valley.

During the month of May, when the large rainfall made the investigation of special value, examinations were made of the effectiveness of the drainage system upon a farm at Cloverhill, Miss., where the soil is known as "buckshot." The rate of movement of the water through the soil was determined by measurements, and also the rate of discharge from the entire system by the outlet tile. These examinations were made by L. L. Hidinger and Omer Fairley, and the data secured are of special value to those desiring to drain buckshot lands.

George R. Boyd supervised the construction of a farm drainage system planned by this Office for the Coast Land Experiment Station, located near Summerville, S. C. The installation of this system will enable the Office and State to learn whether or not underdrains will be serviceable in the improvement of the coast lands of South Carolina.

THE RECLAMATION OF LEVEL SWAMP LANDS.

A survey and plans were made by H. A. Kipp for the drainage of Toisnot Swamp, containing 2,500 acres, in Wilson County, N. C., and S. H. McCrory made a survey and plans for the drainage of 14,000 acres of the Angola Bay Swamp, in Pender County, N. C., the land in the latter project belonging almost entirely to the State. Arrangements are being perfected by the owners to construct the works recommended by the Office during the coming year.

A survey and plans were also made for the drainage of Sampit Swamp, in Georgetown County, S. C., by H. A. Kipp. It is expected that this work will be constructed under the provisions of the State drainage law, which was enacted in February, 1907.

A drainage district, including about 15,000 acres in Madison Parish, La., was surveyed, the plans for which include the improvement of all of the natural drainage channels. The survey was made by F. F. Shafer, under the supervision of Arthur E. Morgan.

In Arkansas drainage plans for a district of 25,000 acres, located in Ashley County, were worked out by F. F. Shafer, under the supervision of A. E. Morgan. The plans included complete estimates and the preparation and submission of a report in detail to the county court, as required by the State law.

Plans were also made for the general drainage of the Upland Rice country in the vicinity of Lonoke, in Lonoke County, Ark.

The Florida investigations, begun the previous year, were continued by a field party in charge of Lawrence Brett, under the supervision of J. O. Wright. Investigations were made to find a practical route for the shortest drainage channel which could be constructed from Lake Okeechobee to the Atlantic coast. The lake itself and the streams which enter it from the north and the natural outlets to the south and west were examined. These investigations, together with those made the previous year, constitute the data which will be used in making a report upon the drainage of the Everglades.

Three projects for the betterment of the land in the Yazoo Delta, Mississippi, were worked out with greater or less detail during the year under the supervision of W. J. McEathron.

In Tunica County the McKinney Lake district, including 30,000 acres, was surveyed by D. G. Miller, with reference to the construction of a central main drainage canal which should discharge into Moon Lake.

A large area of land in Bolivar County, Miss., was covered in a survey made by S. H. McCrory, the map and report of which show the drainage areas into which it should be divided, the natural channels which should be improved, and new ditches and other works which will be required in carrying out a drainage scheme for the county.

Possible cut-offs for the Coldwater River in its upper sections were investigated by L. L. Hidinger. The surveys in this section were connected with those of Tunica County, the map and report showing the relation of the two in any general drainage scheme. Typewritten reports, accompanied by blueprint maps of each of these projects, have been transmitted to the proper local authorities.

PROTECTION FROM OVERFLOW OF FARM LANDS.

The investigation of flooded conditions along the Neosho River, Kansas, begun during the preceding year, was completed by a party in charge of Lawrence Brett under the supervision of J. O. Wright. A plan for the prevention of further injury by the overflow of the valley was made, in which a system of levees extending from Emporia to the south line of the State, together with sluices, and the general cleaning out of the stream, were recommended. This report

was submitted in typewritten form, accompanied by blueprint maps, and was later embodied in Bulletin No. 198 of this Office.

In cooperation with the Illinois Geological Survey, an investigation of the Little Wabash River and its tributaries, was begun to determine the damage caused by the overflow of the rich farming lands of the valley and the best means of preventing such injury. The field work was in charge of L. L. Hidinger, under the supervision of W. J. McEathron, and the report and recommendations will be submitted to the Internal Improvement Commission of the State of Illinois.

A survey of several other river projects, begun during April and May, will not be completed until the next fiscal year.

THE DRAINAGE OF IRRIGATED LANDS.

C. F. Brown has general charge of the drainage experimental work in Utah and the Grand River Valley of Colorado. Surveys and plans were made in nine of the counties in Utah, the landowners constructing the works in accordance with the plans recommended. With the exception of Washington County and Emery County, the methods used have proved eminently successful and satisfactory to the landowners. The peculiar difficulties in the two counties named are still the subject of investigation.

R. A. Hart, D. G. Miller, and H. R. Elliott were added to the force, the latter two being placed in charge of special investigations in the vicinity of Delta, Montrose, and Grand Junction, Colo., where the injury from overirrigation is so strikingly manifest as to alarm owners of lands in those sections.

An experimental tile-drainage system was installed on the State Experiment Station farm at Laramie, Wyo., by C. F. Brown, in accordance with plans made by this Office. This is the first drainage attempted in Albany County to reclaim land which has become wet and contains alkali to an injurious amount.

Assistance was also given to the people of Greybull Valley in the Big Horn Basin of Wyoming, in the vicinity of Otto and Burlington, where the injury (noted in the report of this Office for 1903) has grown to an alarming extent.

An extended survey of lands injured by alkali, in San Luis Valley in the vicinity of Monte Vista and La Jara, Colo., was made by A. E. Morgan and S. H. McCrory. Complete plans and recommendations were made for the drainage of several areas, and typewritten reports with blueprint maps submitted to the landowners.

The tile-drainage experiment at Lexington, Dawson County, Nebr., was continued, observations being made upon the effect of the drains upon the alkali condition of the soil as indicated by the crops which were planted and cultivated by tenants. A report upon this experi-

ment will be prepared for the State engineer of Nebraska, for insertion in his forthcoming biennial report.

SPECIAL INVESTIGATIONS MADE TO COLLECT TECHNICAL DATA.

During April and May, 1908, L. L. Hidinger and O. G. Baxter conducted a study of run-off conditions and discharge of the ditches in some of the older drained districts in Illinois and Iowa, with respect to the operation of both tile drains and open ditches.

G. A. Griffin made a review of progress in the construction of levees and pumping plants along the Illinois River bottom lands lying between Peoria and St. Louis. This is intended to be supplemental to the report upon that territory prepared by this Office in 1904. The methods of placing assessments upon the land for improvements of this character were especially studied, and also the design and capacity of pumping plants which are being constructed as a part of the works.

F. F. Shafer made examination of ditches in Louisiana and Arkansas, and reported upon the efficiency of the pumping plants used, the manner of maintaining ditches in that section, and also the carrying capacity of drains which are found necessary to accomplish satisfactory drainage.

Studies of the drainage of peat lands in Indiana, Illinois, Wisconsin, and Minnesota, and of the reclamation of tide lands along the Atlantic coast, were made by members of the staff of the Office. Information upon these subjects has also been secured by correspondence with careful observers.

DISSEMINATION OF INFORMATION.

In addition to the extensive correspondence carried on continually from the Washington office, by means of which much information of a special and definite character was given to inquirers, members of the staff made addresses and took part in public meetings in which the subject of drainage was considered. Among the more important of these were farmers' meetings in North Carolina, Nebraska, Arkansas, Louisiana, and Colorado; a meeting of the American Peat Society at Norfolk, Va.; farmers' meeting at Georgetown, S. C.; the annual meeting of the Minnesota State Engineers Society; and a Good Roads and Drainage Convention at Jackson, Tenn.

THE PROMOTION OF AGRICULTURAL EDUCATION.

The past year has been one of rapid and healthy growth in all phases of agricultural education. Preparations for the third session of the Graduate School of Agriculture were completed, graduate schools offering courses in agriculture were established in Illinois and

Massachusetts, faculties and courses of study were reorganized on broader lines in Alabama, Georgia, Massachusetts, Oregon, Rhode Island, South Carolina, and Wisconsin; teachers' colleges or departments affording instruction in agriculture for teachers were organized in Indiana, Michigan, and Nebraska; summer schools for teachers were held in more of the agricultural colleges than ever before; and the short courses for adult farmers developed rapidly. New agricultural and mechanical colleges were established in Hawaii and Porto Rico. The funds provided by the States and Territories for the agricultural colleges are becoming more and more liberal, and the buildings completed or in process of construction are more commodious and substantial than formerly and are better designed to meet the needs of students and instructors.

Secondary courses in agriculture have been announced by the agricultural colleges in Oregon, South Dakota, Texas, and Virginia, the appropriation for each agricultural high school in Alabama has been increased from $2,500 to $4,000, several of the district agricultural schools in Georgia have been opened, a system of judicial-district agricultural high schools has been provided for in Oklahoma, and permissive legislation for county agricultural high schools has been enacted in Michigan and Mississippi. New York has made appropriations for two additional agricultural high schools, and the Virginia general assembly has voted $20,000 to inaugurate secondary instruction in agriculture and home economics in each Congressional district.

The legislatures of Oklahoma and West Virginia have enacted laws requiring the teaching of agriculture in all rural schools. The club movement to encourage school children to engage in crop growing, cooking, and sewing contests is rapidly extending to all parts of the Union and is becoming an effective agency in arousing an interest in vocational instruction. There has been unusual activity in the preparation and publishing of text-books and other aids in elementary agriculture.

Briefly, the year has been noteworthy for the attention given to providing facilities for graduate study in agriculture, to reorganizing and strengthening college courses, and to multiplying opportunities for acquiring secondary and elementary instruction in this subject. The growing activity in all phases of agricultural education in this country has been faithfully reflected in the larger demands made upon this Office for such information as it has been able to gather from constant study of the literature of American and foreign colleges and schools of agriculture and from personal contact with many of the institutions and men engaged in promoting agricultural education and research in the United States.

This feature of the Office work has engaged much of the Director's time and practically all that of the Specialist in Agricultural Education, Mr. D. J. Crosby, and three clerical assistants. There have been publications to prepare, courses of study to outline for new schools, conferences and conventions to attend, the Graduate School of Agriculture to prepare for, lectures to give at summer schools for teachers, committee work for several educational associations, a large correspondence to conduct, a directory of agricultural investigators and teachers to revise, and the literature of agricultural education to review, abstract, and index. It is to be regretted that the resources of the Office have not enabled it promptly to collate and publish the information it has collected, nor to meet many of the direct appeals from educators for advice and assistance, but there is encouragement in the fact that Congress has granted a small increase in the appropriation for this work.

FARMERS' INSTITUTES.

During the past year the Office through the Farmers' Institute Specialist, Prof. John Hamilton, has continued to conduct investigations and to collect information respecting farmers' institutes and similar organizations in this and in foreign countries, and has cooperated with State officials in charge of institutes in carrying on their work.

Farmers' institutes were held during the year in all of the States excepting Louisiana and Nevada, and in all of the Territories excepting Alaska and Porto Rico. The work has been steadily growing both in interest and public appreciation.

The attendance for the year at the regular institutes was over 2,000,000, an increase of almost 470,000 over that of 1907. Special institutes also were held with a reported attendance of over 340,000, making the total for the year at all forms of institutes 2,438,682 The special institutes were composed of independent and round-up institutes, railroad specials, movable schools of agriculture, and field meetings for conducting demonstrations. Women's institutes were held in 15 States, institutes for boys in 5 States, and normal institutes for training institute lecturers in 5 States. There were, besides, numerous street fairs, farmers' picnics, and harvest-home meetings.

The appropriations for the year for institute purposes by 47 States and Territories amounted to $325,569, an increase of $41,118 over 1907.

Eleven hundred lecturers were employed by the State directors in giving instruction. Of this number, 426 were members of the faculties of the agricultural colleges and staffs of the experiment stations. These college and station men contributed 3,851 days of time

to giving instruction in the institutes, or 295 days more than were contributed by them during the previous year, showing increasing interest on the part of the colleges and stations in this form of extension work.

In a number of States the institute authorities have undertaken to supplement the work of their regular institutes by extending the meetings for a considerably longer period than was formerly the custom. In one locality the meetings were continued during eight weeks, the sessions being held at night, while during the day the institute lecturers were employed visiting the farmers of the community, offering advice, and directing demonstrations in the field.

In another State the institute officials purchased a car and equipped it with a complete outfit for conducting a school of agriculture. Students throughout the State were registered in advance, agreeing to attend all of the sessions. The course consisted of six lectures supplemented by field demonstration meetings held on farms and in orchards, stables, and poultry yards. The schools were continued for one month, with a total registered attendance of over 1,700 students.

In another State over 1,100 men and 1,000 women were registered for attendance upon short courses held at fifteen different points and each continuing for one week. Every male student was required to pay a registration fee of $2 and each female student a fee of $1. The success of the schools was so pronounced that the directors have arranged for 24 short courses for men and 10 for women for the coming year.

The time seems to have arrived in many of the States for expanding the farmers' institutes to include other forms of extension work than those heretofore employed. Short courses, field demonstration work, normal institutes, institutes for boys and girls, and institutes for women are some of the directions which this expansion might take. Much of the work of the institute office has therefore been in the direction of devising methods of itinerant instruction in agriculture suited to rural conditions and to securing the cooperation of State and local officials in operating these courses with a view to thereby increasing production and otherwise improving the everyday practice of farming people. The Office has been cooperating with the agricultural colleges and experiment stations in devising plans for conducting extension work. In this cooperation the Office through its institute specialist has collected information respecting the forms of extension work in operation in this and in foreign countries, and has turned over this information to the committee on extension work of the Association of American Agricultural Colleges and Experiment Stations, and has also aided the committee in formulating the information and in editing and publishing its reports.

The work of the institute specialist in general has been: Collecting data respecting the condition and progress of farmers' institutes of the United States and in foreign countries; lecturing before representative farmers' institutes and other educational assemblies; preparing and editing bulletins, illustrated lectures, courses of study for movable schools of agriculture, charts for use in institute teaching, and reports upon institute work; distributing agricultural literature; supplying institute officials with expert advice; conducting correspondence with persons interested in agricultural education; conducting investigations into the methods of education in agriculture for adults in the United States and foreign countries; collecting and compiling the laws of the several States and Territories relating to the farmers' institute work; visiting educational institutions in the interest of college extension work; conducting investigations into the work of college extension; preparing programme and securing speakers for the annual meeting of the Association of Farmers' Institute Workers, and compiling and editing the reports of the association; securing the names and addresses of farmers' institute lecturers in the United States, together with a list of the topics that they each discuss and a personal history statement from each lecturer; and acting as clearing-house agent in securing speakers from this Department and from other sources for institute service.

The Office has also prepared and published during the year as bulletins and circulars relating to the institute work the Annual Report of the Farmers' Institute Specialist, the Proceedings of the American Association of Farmers' Institute Workers, and a revised list of farmers' institute directors and lecturers. There have been prepared under its direction a syllabus of an illustrated lecture upon tobacco growing, a course of study on cereal foods for movable schools of agriculture, and a set of charts upon selecting cattle for feeding purposes.

PUBLICATIONS.

The publications of the Office during the past year were of the same general character as in previous years, comprising as heretofore five main classes, as follows: (1) Annual reports, including the administrative report of the Director and the larger annual report of the Office. (2) Experiment Station Record, which gives a technical review of the current literature of agricultural investigation throughout the world, and Experiment Station Work, which is published periodically in the Farmers' Bulletin series of the Department and gives a popular summary of some of the more salient practical results of the work of the experiment stations. (3) Publications relating to the food and nutrition of man, consisting of technical and popular bulle-

tins, circulars, etc., reporting or based upon the results of nutrition investigations conducted under the auspices of the Office. (4) Publications relating to irrigation and drainage, which include reports, technical and popular bulletins, circulars, etc., giving the results of the irrigation and drainage investigations of the Office. (5) Educational and other publications, including those relating to agricultural education in general, farmers' institutes, proceedings of the Association of American Agricultural Colleges and Experiment Stations, and of the Association of Farmers' Institute Workers and similar publications, and the card index of experiment station literature, besides miscellaneous documents of various kinds. The editorial management of the publications of the Office, with the exception of the Experiment Station Record, is in charge of Mr. W. H. Beal.

During the year the Department published 68 documents prepared by this Office, not including revised reprints, separates, etc., aggregating 3,839 pages. These documents included 13 numbers of the Experiment Station Record, 12 technical bulletins, a report of the Alaska experiment stations, 3 bulletins and 2 reports of the Hawaii Experiment Station, a report of the Porto Rico Experiment Station, 2 reports of the Office, and 8 Farmers' Bulletins (including 6 numbers of Experiment Station Work), 5 circulars, 12 monthly lists of experiment station publications, and various miscellaneous documents. Two other numbers of the Experiment Station Record, 1 technical bulletin, 1 annual report of the Office, 1 Farmers' Bulletin, 3 articles for the Yearbook of the Department, and several miscellaneous documents, containing about 800 pages, were prepared and submitted for publication before the close of the fiscal year. Seventeen separates of individual articles contained in larger reports, aggregating 547 pages, were reprinted in editions of varying size to supply requests for the articles.

Several of the earlier technical and Farmers' Bulletins prepared in this Office were exhausted during the year and were reprinted, in several cases with complete revision or more or less important additions and corrections.

The report of the Chief of the Division of Publications shows that about 2,360,000 copies of publications prepared by this Office, of which 1,864,000 were Farmers' Bulletins, were issued during the past fiscal year ended June 30, 1908.

The number and volume of publications issued during the year were somewhat smaller than in previous years, but this was due largely to temporary causes. It is to be expected that the amount of publication will steadily increase with the normal growth of the various lines of work of the Office, and this will render a modification of present printing limitations very desirable if not necessary.

INCOME.

The income of the Office during the past fiscal year, derived wholly from appropriations by Congress, was as follows:

For the general business of the Office	$61,220
For the Alaska experiment stations	24,000
For the Hawaii Experiment Station	24,000
For the Porto Rico Experiment Station	24,000
For investigations on agricultural schools and farmers' institutes	5,000
For nutrition investigations	5,000
For irrigation and drainage investigations	150,000
Total	293,220

WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS.

By E. W. Allen.

REVIEW OF THE YEAR.

One of the most notable features of the year was the increased popular demand for a closer knowledge of the results of experiment-station work, and the provision of special facilities to that end. Additional substations, demonstration farms, and test fields were provided in several States; extension work to carry the results to the farmers was organized in a more systematic way; the publication of popular accounts of the station work in circulars, popular bulletins, and newspapers received increased attention; and in various other ways special effort was directed toward making the teachings of the stations available to the farmers and studying their problems in their midst.

Branch or substations to study problems of local importance were established in Arizona, Arkansas, Idaho, and South Carolina, among others, and those already existing in many other States were given increased support. In Wisconsin an arrangement was effected whereby the station may conduct systematic demonstration work on the farm of one of the State insane asylums. In Kansas and Missouri legislation was enacted providing for the establishment of county demonstration farms under the general supervision of the station. The dissemination of results through agricultural experimenters' unions, made up in whole or in part of former agricultural students, was continued in Nebraska, New York, and Wisconsin, and a similar organization was effected in Rhode Island.

With the increased desire for the popularizing of station work, the need of a form of publication distinct from the regular bulletin series was generally felt. The Massachusetts, Michigan, New Hampshire, Cornell, Oregon, and Virginia stations were added to the list of those issuing a series of circulars, and the Washington Station began a series of popular bulletins. The North Dakota and Wisconsin stations began furnishing press bulletins, and the Connecticut State Station distributed what are known as "post-card bulletins," similar in form and size to ordinary postal cards.

The tendency toward greater differentiation of college, station, and extension work was continued to a marked degree. In New Mexico the directorship of the station was separated from the presidency of the college, with which it had always been combined, and in Texas, where the offices had been reunited during the previous year, a separation was again effected. There are now but two institutions, Nevada and North Dakota, in which the presidency and directorship are not distinct. A more complete differentiation of instruction and experimental duties among the staff was brought about in Florida, Mississippi, Pennsylvania, and South Carolina especially, and in many other stations the principle was recognized by relieving the station men of heavy teaching duties.

The matter of greater attention to the preparation and editing of publications also received considerable attention by the stations. In Wisconsin a bulletin editor was appointed, and in Florida this duty was assigned to a station officer. In several other stations a special editor had previously been provided for this work. The New Hampshire Station adopted the plan of reprinting the scientific articles based on work done at the station and contributed by members of its staff to scientific journals, issuing these as a numbered series for distribution to station and department libraries.

Many of the stations received increased support from their respective States, this taking the form of appropriations for buildings and equipment, for general maintenance, and very commonly for the inauguration or extension of specific lines of work. In Indiana what is believed to be the largest and most complete building in America devoted exclusively to station work was constructed at a cost of about $100,000. Since the close of the year the Indiana legislature has also increased its annual appropriation to the station from $25,000 to $75,000, of which $10,000 is for general expenses and a like amount for extension work.

The Porto Rico legislature provided for a new station building to cost $20,000, and Delaware appropriated $10,000 for new buildings on the college and station farm. New agricultural buildings for the joint use of the college of agriculture and the station were dedicated in Maine, Pennsylvania, Tennessee, and Vermont. There was under construction the $400,000 agricultural building in Iowa and a substantial agricultural hall in Oregon. The corner stone has been laid for a $100,000 agricultural building in Missouri, and a similar building has been authorized in Michigan.

In Wisconsin, buildings for agronomy and agricultural engineering were completed and an animal-husbandry building was begun. The New York State Station received $32,500 for the construction of five residences for heads of departments. The Kentucky and North Da-

kota stations were granted $8,000 and $6,000, respectively, for greenhouses, and the Wyoming Station $8,000 for station barns. Numerous smaller structures were also provided for several institutions.

In Montana the State appropriation to the station was increased nearly 50 per cent, and in Ohio there was an increase of nearly $35,000, the aggregate State appropriation now being about $125,000. The Kansas Station was given $30,000, the Utah Station $33,500, and the Washington Station $29,600, a large part of which in each case was for the maintenance of substations.

The new lines of work taken up by the stations include tobacco investigations in Pennsylvania, animal nutrition in Vermont, floriculture in Illinois, entomology at the Connecticut Storrs Station, pathological work with forest trees at the Hawaiian Sugar Planters' Station, alkali investigations in Wyoming, bacteriological work in Louisiana and Mississippi, and dry farming studies in Arizona. Special State funds were provided for many of these undertakings. A department of animal industry was added in South Dakota, and a department of animal nutrition in Minnesota. In California, the facilities for investigation relating to citrus fruits were materially increased in the southern part of the State.

Following an appropriation by Congress of $5,000 for the establishment of a Federal experiment station in Guam, arrangements were made for the opening and maintenance of such a station. A site has been selected at Agaña, where a tract of about 27 acres is being fitted up. Experiments are under way with corn, tobacco, coffee, and leguminous trees and plants, with a view to the improvement of the present primitive agricultural practice of the island.

With a view to the development of the trucking industry, the Virginia Truck Station was established at Norfolk, Va., the State and the State board of agriculture and immigration furnishing funds and local truck growers providing the land and equipment. The work thus far undertaken deals with studies of the fertilizer requirements of truck crops on the Norfolk sands, insect and plant diseases affecting truck crops, and plant breeding with special reference to strawberries and peanuts.

Another new agency in agricultural research in this country, although not associated with the stations, was provided toward the close of the year through the conversion of the Bussey Institution of Harvard University, which had been conducted since its establishment in 1870 as a school of agriculture and horticulture, into an institution for advanced instruction and research in agricultural science. The lines of work thus far undertaken include economic entomology, animal heredity, experimental plant morphology, and comparative pathology.

WORK UNDER THE ADAMS ACT.

Research under the Adams Act has continued on the same plans outlined by the Office in previous reports. In administering the Adams fund the Office has maintained its policy that the expenditures from it must be restricted to lines of work which involve original features and are of a research character. Special attention has been given to this in the examination of the accounts, and the attitude of the Office is now well understood.

A few lines of investigation started under this fund have been completed, and the increasing appropriation has made it possible to enter upon several new projects. The latter are referred to in the reports on the individual stations. The policy of restricting the number of projects and making the work upon them comprehensive and thorough has been strongly urged. As a result of the standard maintained by the Office, several projects originally proposed and started under this fund have been transferred to other funds. Changes in staff have also led to a few projects being discontinued or abandoned. It has been urged that when such changes occur a continuance of the lines of research be considered in choosing new men; but in the nature of the case such continuation can not always be provided for, owing to the interests of the men and their desire to inaugurate or continue investigations of their own. This difficulty in maintaining continuity should be given due weight when the question of losing a member of the staff comes up. An investigator becomes more valuable to a station by reason of his having inaugurated and made encouraging progress in a research problem, and all reasonable effort should be made to retain him until his project has been definitely concluded.

In several instances entire departments have been placed under the Adams fund, with the plan to devote them exclusively to researches under it. This arrangement is a simplification in classifying the accounts by funds, but it often assigns to the research fund certain expenses for general maintenance, library, repairs, etc., which raise a doubt as to their propriety. Usually, also, the men connected with these departments can not avoid a certain amount of routine work which is not directly related to their projects; and apart from this it is doubtful whether it is wise to confine most men entirely to investigation which will cut them off from contact with the more practical side of station work or that which wins expressions of popular approval. At all events difficulties will arise in supporting departments entirely from the Adams fund when this includes charges for the general maintenance of the department, care of buildings, etc., and the Office has advised against such a course.

The problem of a suitable organ for the publication of investigations and researches of a more scientific character has not yet been solved. In their details such investigations are not suited to distribu-

tion to the farmers in the form of bulletins, but they have a special interest to station workers, teachers, and others, and it seems quite important that they should be brought together in some publication which will make them generally available.

STATISTICS OF THE STATIONS.

Agricultural experiment stations maintained in whole or in part by Federal funds now exist in every State and Territory, including Alaska, Hawaii, Porto Rico, and Guam. The total amount expended for this purpose during the fiscal year ended June 30, 1908, was $2,800,047.29, of which $1,152,000 was received from the National Government. The remainder, $1,648,047.29, came from the following sources: State governments, $947,558.67; individuals and communities, $22,835.30; fees for analyses of fertilizers, $186,159.70; sales of farm products, $210,391.28; miscellaneous, $281,102.34. In addition to this the Office of Experiment Stations had an appropriation of $293,220 for the past fiscal year, $24,000 each for the Alaska, Hawaii, and Porto Rico experiment stations, $5,000 for nutrition investigations, $150,000 for irrigation and drainage investigations, and $5,000 for farmers' institutes and agricultural schools.

In Alabama, Connecticut, Hawaii, Louisiana, Missouri, New Jersey, New York, and North Carolina separate stations are maintained wholly or partly by State funds, and in a number of States substations are maintained. Excluding substations, the total number of stations in the United States is 61, of which 55 receive Federal funds.

PROGRESS IN FOREIGN COUNTRIES.

One of the most notable events in the organization of agricultural research in foreign countries during the year was the inauguration of an experiment station system in Portuguese East Africa, or Mozambique. This region covers nearly 300,000 square miles on the east coast directly opposite Madagascar, and has a population of about 3,000,000. Its resources are believed to be very great, but are at present largely undeveloped. Mr. O. W. Barrett, of this Department, formerly entomologist and plant pathologist of the Porto Rico Station, was selected by the Portuguese Government to organize the stations, and began work in the spring of 1908. It is planned to establish a central station at Lourenço Marquez, and three substations, embodying a total area of probably more than 3,000 acres, the substations to be located at Chai-Chai on the Limpopo River, at Inhambane south of and at Quelimane north of the Zambezi River.

A bequest approximating $50,000 a year was made by the late John Innes, which bids fair to prove of great benefit to British horticulture. Under the terms of this bequest, a body of trustees is to estab-

lish and maintain an institution to be known as the John Innes Horticultural Institution, which is to have for its object the promotion of horticultural instruction and research. The direct management of the institution, and such other matters as the trustees may determine, devolves upon a council of twelve persons, of whom the three trustees are ex officio members, and the remainder selected from specified societies and universities in England. The house and a portion of the grounds of Manor Farm, Merton, England, have been bestowed for the purposes of the institution and for the establishment of a horticultural station, which is to be efficiently equipped. The trustees are further empowered to establish and equip similar stations in other parts of the country or assist in such work.

A laboratory and research station at the Wisley Gardens, Surrey, has been opened under the management of the Royal Horticultural Society. A one-story building, fitted up with a students' laboratory, a small research laboratory, a photographic room, and a small glass annex for experiments in plant physiology and pathology has been erected, together with a range of greenhouses, the total cost being about $8,000.

The Chinese Government has taken steps toward the development of agricultural instruction and research in Manchuria, and E. C. Parker, assistant agriculturist in the Minnesota University and Station, and W. H. Tomhave, assistant in animal husbandry in the Pennsylvania College and Station, have been appointed expert advisers in agriculture. One of the features contemplated is the establishment of an experiment station at Mukden.

An appointment was made by President Diaz, of Mexico, of a director of agricultural instruction and experimental work in that country. One of the first undertakings was the removal of the National School of Agriculture from San Jacinto to a site near the City of Mexico, where land was provided sufficient for both instruction and experimental work.

In Brazil, a national congress of agriculture, held to consider means for the improvement of agricultural conditions in that country, recommended as one of the means to be adopted the establishment of a system of experiment stations similar to that in this country.

The Spanish Government authorized the establishment of an experiment field with irrigation equipment on the Santa Teresa estate, near Seville, for educational and experimental purposes, a laboratory and educational institution in connection with the agricultural school at Madrid, and an experiment field at Motril, in the Province of Granada. The organization and equipment of these institutions has been placed in charge of the state engineer for agriculture of East Andalusia, under the supervision of the general director of agriculture of the ministry of public works.

An experimental garden was opened at Peradeniya, under the auspices of the Ceylon Agricultural Society, and a rice experiment station was begun at Vercelli, Italy. An annual appropriation of about $97,000 was made for the improvement and cultivation of the native plants of Tunis, a portion of which is to be used in the establishment of experimental farms.

On account of the lack of room for expansion necessitated by the great increase in its work, the agricultural experiment station at Marburg, Germany, is to be removed to Cassel, where it will be connected with the pomological institute at Oberzwehren. A state department of apiculture, which includes a scientific division, was established in connection with the zoological institute of the University of Erlangen.

An elaborate set of buildings for the sugar experiment station at Pekalongan, West Java, has been completed. The buildings include several laboratories and offices, a library, and a large museum. A laboratory and office building was erected for the department of agriculture of the Federated Malay States at its rubber experiment plantations at Kuala Lumpur. This is a two-story building 130 feet long, containing a capacious chemical laboratory and other laboratories for the director, the government mycologist, the entomologist, the superintendent, and other scientific workers, as well as a library and offices.

INSPECTION OF THE STATIONS.

In accordance with the fixed practice of the Office, a personal inspection was made of the work and expenditures of all of the experiment stations receiving Federal funds during the past year. Four members of the Office force took part in this inspection, viz, the Director (A. C. True), Assistant Director (E. W. Allen), W. H. Beal, and Walter H. Evans.

The following reports are based upon the results of this inspection, the annual financial statements of the stations rendered on the schedules prescribed by the Secretary of Agriculture, and the printed and other reports of the stations.

ALABAMA.

Agricultural Experiment Station of the Alabama Polytechnic Institute, *Auburn.*

Department of the Alabama Polytechnic Institute.

J. F. Duggar, M. S., *Director.*

There was little change in organization at this station during the year covered by this report, and the work developed along lines pursued in previous years. The last legislature appropriated a liberal

sum for buildings and equipment of the college, including $75,000, to be available during the current quadrennium, for the erection and equipment of an agricultural building which will house the experiment station as well as the agricultural department of the college. Facilities which such a building would furnish are greatly needed by the station.

Progress was made during the year in several of the lines of Adams fund work enumerated in the report for 1907, the advances being most marked in case of the various plant breeding projects, more particularly with cotton, corn, oats, and peaches. The continuity of the entomological investigations was interfered with to some extent by a change in the head of the department. These investigations now include the following new or modified projects: Effect of hibernation upon the alimentary and reproductive system and upon the vitality of hibernating insects; factors governing the production, diffusion, and insecticidal efficiency of hydrocyanic-acid gas and carbon bisulphid; and life history and economic relations of the fire ant.

The work of the agricultural department was in the main a continuation of field experiments which have been going on for a number of years, including breeding, variety, fertilizer, and culture tests with various field crops, such as cotton, corn, oats, sorghum, cowpeas, soy beans, alfalfa, vetches, clover, and grasses; and rotation of crops. Studies of the fertilizing value of cowpeas and soy beans were also continued, as well as on the effect of lime on acid soils. Tests of methods of making cement tile and fence posts and of creosoting fence posts were carried on. Investigations on cotton shedding and with new forage crops were continued during the year in cooperation with the Bureau of Plant Industry of this Department. Cooperative soil tests with fertilizers with farmers in different localities were continued.

In the animal husbandry department attention has been given to experiments in early lamb production, feeding sheep on various Alabama feeds, and improvement of native sheep by crossing with the Dorset breed; a continuation of cooperative experiments with the Bureau of Animal Industry of this Department in feeding beef cattle and in dairy work; and the establishment of permanent pastures.

The veterinarian has given special attention, in cooperation with the Bureau of Animal Industry of this Department, to studies of the life history of the cattle tick, blood inoculation for immunity against tick fever, and methods of tick eradication, and the bacteriology of the cow's udder and of milk. He has also continued to conduct the farmers' institutes.

The chemical work of the station, aside from fertilizer and feeding stuffs inspection, included a continuation of experiments in sirup making from cane and watermelons, some chemical analyses of vegetables

and other Alabama farm products, the composition of the cotton plant with reference to fertilizer requirements, and a continuation of a study of the effect of humification on insoluble phosphates.

In horticulture, tests of cotton-seed hotbeds and the breeding of disease-resistant peaches were continued. Observations have been made on plantings of varieties of peaches, pears, apples, citranges, figs, etc. Observations on meteorological conditions in relation to the growth of fruits were also carried on and nursery inspection was conducted as heretofore.

The plant physiologist and pathologist continued the study of cotton anthracnose and breeding for resistance to this disease. He has also been engaged in corn breeding, a plant disease survey of the State, studies of apple leaf-rust, cotton wilt (in cooperation with the Bureau of Plant Industry of this Department), and observations on an enzym disease of cotton. Data have been collected with reference to weeds and medicinal and poisonous plants of the State. Since the close of the year the head of this department has resigned to become professor of agricultural botany and botanist of the station at the Nebraska University and Station.

The entomologist, W. E. Hinds, who took charge about the beginning of the year, has given attention particularly to the Adams fund projects in entomology enumerated above.

The following publications of the station were received by the Office during the year: Bulletins 140, Descriptions and classification of varieties of American upland cotton; 141, Texas or tick fever; and 142, Corn breeding in Alabama; Circular 2, Cedar apples and apple leaf-rust; and the Annual Report for 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	13,107.25
Farm products	266.62
Miscellaneous	986.44
Miscellaneous, balance from previous year	228.04
Total	38,588.35

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The work of the Alabama Station has many valuable features. With the increase of its funds and the consequent enlargement of its enterprises there is need of still further differentiation of the station business and the concentration of direct control and supervision in the hands of a director able to give his time and energy quite fully to the station business.

Canebrake Agricultural Experiment Station, *Uniontown.*

F. D. STEVENS, B. S., *Director.*

The Canebrake Station has continued its work along the same general lines as in former years with no change in organization or management.

The fertilizer requirement of the Canebrake soils in cotton production has been the chief subject of inquiry. More attention has been paid to cover crops than heretofore; the necessity of crop rotation has been emphasized.

No extension work has been attempted; during the summer six or seven articles were published in the local paper dealing with cottonseed meal as a food and fertilizer and the value of alfalfa, not only as a food but for its fertilizing effect on Canebrake soils; this was done in an effort to show the planters how unwise it is to depend on Johnson grass. The aim is to teach by example. For instance, in contrast with the common practice of allowing farm animals to wander about the old cotton fields and along the canal banks, this station maintains near the highway fields of alfalfa and of vetch and oats on which the animals are pastured.

There have been no additions to buildings and equipment except in the way of repairs. Two bulletins have been received from this station during the year: 24, Experiments with cotton and corn in 1906; and 25, Experiments with cotton and oats in 1907.

The income of the station during the past fiscal year was as follows:

Balance from previous year	$1,087.56
State appropriation	2,500.00
Farm products	1,270.10
Total	4,857.66

The station receives no part of the Federal appropriations for experiment stations.

The Canebrake Station is serving a useful purpose as a practical example of the value of modern farming methods.

Tuskegee Agricultural Experiment Station, *Tuskegee Institute.*

Department of the Tuskegee Normal and Industrial Institute.

G. W. CARVER, M. Agr., *Director.*

The work of the Tuskegee Station continues along the lines of forage investigations, the growing of alfalfa, cotton breeding, fertilizer experiments, poultry raising, feeding experiments, and the improvement of the soil.

The most important result of the station work is the success it has attained in the matter of overcoming poultry diseases and other difficulties bearing upon the success of poultry raising. The work along that line is very encouraging. The same is true with two or three new types of cotton, one a long-stapled upland variety and the others improved varieties.

The station has distributed a considerable amount of seeds and plants to the farmers in the county with excellent results.

Three bulletins have been received from this station during the year, as follows: Bulletins 11, The relation of weather and soil conditions to the fruit industry of southeastern Alabama; 12, Saving the wild plum crop; and 14, How to make cotton growing pay.

The income of the station is a State appropriation of $1,500.

The work of the Tuskegee Station is a distinct force for agricultural improvement, and is highly appreciated by those whom it aims to serve.

ALASKA.

Alaska Agricultural Experiment Stations, *Sitka, Copper Center, Rampart, Kodiak,* and *Fairbanks.*

Under the supervision of A. C. True, Director, Office of Experiment Stations, United States Department of Agriculture.

C. C. Georgeson, M. S., *Special Agent in Charge, Sitka.*

The work at the several stations has been continued along the lines described in previous reports. A few changes have been made in the personnel of the stations during the past year. J. W. Gasser, a graduate of Kansas Agricultural College, has succeeded F. E. Rader as superintendent of the Rampart Station; J. W. Neal, for several years superintendent of the station at Copper Center, has returned to Alaska and has been placed in charge of the newly established station near Fairbanks; and P. H. Ross resigned from the superintendency of the Kenai Station. No successor was appointed to have charge of the Kenai Station. The land has been leased and work will be begun again if it is found desirable to do so. The work at this station has been largely confined to animal breeding, dairying, and the raising of forage for live stock. The construction of a railroad across the upper end of the Kenai Peninsula has isolated the village of Kenai to such an extent that communication with the station has become exceedingly difficult. The conditions of climate, etc., at Kenai and Kodiak do not differ very materially, so it has been thought best to combine the work on Kodiak Island, and as a result all the live stock and dairy apparatus have been moved to Kodiak, where a stock-breeding station was established in 1907.

At the Sitka Station the most attention has been given to horticultural operations and plant breeding. Extensive experiments have been inaugurated in plant breeding in an effort to secure better and hardier fruits. Hybrids have been secured between the wild and cultivated strawberry and between the native salmon berry and the cultivated raspberry, and some fruited this year for the first time. It is hoped that some of the hybrids will prove worthy of further propagation. A large number of pollinations of the native crab apple were made, but through accident all the fruits were lost. The work in testing apples, plums, and cherries has been continued. After several attempts the Sitka Station has begun systematic experiments in poultry raising, and as soon as possible poultry houses and ranges will be erected and several promising breeds of chickens will be introduced for experiments on their adaptability to Alaskan conditions.

At the Copper Center and Rampart stations cereal investigations are receiving most attention, and selection experiments are being continued to obtain early ripening strains of oats, barley, and wheat. At Rampart these cereals have ripened every year since 1900, and it seems probable that winter varieties of wheat will be secured that will withstand the average winter of that region and ripen every year. At Copper Center less success has been attained, as early frosts have repeatedly destroyed the bulk of the crops before their maturity. At this station considerable work has been done with native grasses and leguminous plants, and a number of species are being grown under cultivation to test their adaptability for domestication. At both stations the growing of potatoes and other hardy vegetables is being given attention.

During the past fiscal year work was begun at the Fairbanks Station, land for which was set aside by Executive order in 1906. Thus far the work has been mostly of a pioneer character and consisted largely of clearing the land and preparing it for cultivation and the erection of buildings, fences, etc. About 10 acres were prepared and planted during the year, the principal crops being potatoes and oats for stock feed. Some experimental work was begun on a series of plats, but on account of the newness of the soil these investigations can not be made an important feature until the land has been reclaimed and continued under cultivation for a few years. The land at the Fairbanks Station is representative of a large area in the Tanana Valley capable of agricultural development, and it is hoped soon to demonstrate the practicability of agriculture in this region.

The animal breeding work has been consolidated on the island of Kodiak by the transfer of all the live stock from Kenai late in 1907. There are now at the station about 60 head of pure-bred Galloway cattle that have demonstrated their hardiness and adaptability to their surroundings. The present reservation has proved too small

and not well suited to a live-stock station, and a larger tract in what is believed to be a better location has been selected at some distance from the village of Kodiak. When this tract is secured the herd will be divided, only the dairy animals and experiments in dairying being continued at the present place. The principal energies at Kodiak will have to be devoted for a time to the erection of buildings and fences.

The only publication of the station for 1908 was the Annual Report.

The revenues of the Alaska stations for the fiscal year ended June 30, 1908, were as follows:

United States appropriation	$24,000.00
Farm products	4,987.84
Total	28,987.84

The work of these stations is having an important effect in determining under pioneer conditions the agricultural possibilities of the different regions. The appreciation of the stations' efforts are shown in the increasing inquiries for information, seeds, plants, etc. The work with live stock is being watched with interest as an important factor in the future agricultural development of the country.

ARIZONA.

Agricultural Experiment Station of the University of Arizona, ***Tucson.***

Department of the University of Arizona.

R. H. FORBES, M. S., *Director.*

Few changes in personnel took place during the past year at the Arizona Station, and definite progress was made along several important lines. An especially important result accomplished was the determination of underground water supply in the valleys immediately adjacent to Tucson, and the formation of a financial and engineering plan whereby this supply may be utilized. The principal investigations carried on during the year were along exactly the same lines as the year before.

Investigations under the Adams Act in general made noteworthy progress, especially as to results with theoretical deductions relating to the operation of enzyms in dates, with reference to a better understanding of the effects of minute quantities of copper upon field crops, with reference to Fusarium diseases, and especially with reference to the study of underground water supply of an arid-region river. The results of this latter study added decidedly to the knowledge of a strong economic subject vitally affecting the welfare of the arid region. Facilities for these lines of work were not greatly added to

during the year, having been provided for the most part during 1907. The Southern Pacific Railroad donated $2,500 for the prosecution of irrigation investigations.

New Adams fund projects were begun or planned, as follows: Study of the nutritive value of one or more of the most promising economic fungi; corrosion of metallic parts of machinery under water by electrolysis and otherwise; and the olive. The last project is one that was taken up at the station several years ago and afterwards discontinued.

Other lines of work included range investigations relating to the character and conservation of forage supply in semiarid regions; sheep breeding experiments with reference to the production of a type of sheep especially suited to the warm irrigated valleys of Arizona; horticultural investigations, with especial reference to citrus fruits, figs, and grapes; and miscellaneous agricultural investigations. The main general survey of forage conditions on Arizona ranges was completed and progress was made along the other lines.

Cooperative work was continued with the Bureau of Plant Industry in connection with date-palm investigations and range study. Extension work other than cooperative experiments was continued during the year in the form of farmers' institutes, for which a special Territorial appropriation has been utilized. This work is undoubtedly of great value for the information both of farmers and of the station staff engaged in it. Institute work, however, is not prosecuted to such an extent as to detract seriously from the experimental work in which all members of the station staff are chiefly engaged.

The biennial Territorial appropriation of 1907 continued during the past year for the support of demonstration work at Yuma and for the printing of publications. There was also an appropriation of $1,745.84 for farmers' institutes.

The following publications were received from this station during the year: Bulletins 55, Cement pipe for small irrigating systems and for other purposes; and 56, The scale insects of the date palm; The extermination of the date-palm scales; and the Annual Report for 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Territorial appropriation	5,252.53
Southern Pacific Railroad	2,500.00
University apportionment	961.30
Farm products and live stock	1,628.09
Miscellaneous	189.49
Total	34,531.41

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The work of the Arizona Station is steadily increasing in practical and scientific importance and is becoming better appreciated and supported.

ARKANSAS.

Arkansas Agricultural Experiment Station, *Fayetteville.*

Department of the University of Arkansas.

C. F. ADAMS, B. Agr., A. M., M. D., *Acting Director.*

Numerous changes in personnel have taken place at the Arkansas Station since the previous report was made. The chemist resigned and was succeeded by W. M. Bruce, of the University of Chicago; H. D. Young was appointed assistant chemist for Adams fund work; Martin Nelson, of the Nebraska University and Station, was appointed agronomist to fill the vacancy caused by the resignation of the former incumbent; R. J. Nelson, field agent, was made assistant professor of agriculture in the college; and J. F. Standford was appointed assistant in the department of pathology and bacteriology.

The Adams fund projects outlined in last year's report were carried on and satisfactory progress made; the work on anthrax and anthrax vaccines was completed.[a] No new projects were begun.

In addition to Adams fund work, the department of pathology and bacteriology was occupied with an investigation of the relative value of hog feeding by alternate wide and narrow rations (at short intervals), as compared with uniform rations of the same total nutritive value.

As in previous years, the veterinarian devoted much time to the work of tick eradication in the northern part of the State. Another line of work was in connection with outbreaks of glanders in various sections of the State. The disease centers were eliminated and the further spread of the disease prevented. Tuberculosis in the herd of the State Hospital for Nervous Diseases was studied, and a pasteurizing plant was established in the hospital dairy.

The department of entomology carried on important work in connection with the San José scale; a bulletin on the distribution of this pest has been published since the end of the fiscal year. Nursery

[a] See Arkansas Sta. Bul. 97.

inspection was carried on as usual, and progress was made in an effort to record all the economic insects which occur in the State. This is considered quite important, as the State is not well known from the standpoint of economic entomology. Several species of plant lice were studied in their relation to plant diseases.

The agricultural department carried on variety tests of cereals, cotton, and grasses; fertilizer tests; improvement by selection of wheat, oats, rice, cotton, barley, and corn; tests of tile drains; rotation experiments; tests of different methods of cultivation of corn and cotton; and pot experiments with soils from representative areas of the State.

The chemist cooperated with the horticulturist and the pathologist in Adams fund work. Other work consisted of routine analyses, some nutrition investigations, experiments on the digestibility of the forage crops of the State, and a study of the origin of the so-called "prairie-dog" mounds of the State. A meteorological summary from 1891–1907, inclusive, was published.

The dairyman experimented with various rations for dairy cows, and studied the control of the moisture content of butter and a comparison of cream-ripened and butter-ripened butter. Work in these various lines is continued.

The horticulturist continued the demonstration of the treatment of a run-down orchard, and has succeeded in producing apples of improved quality as well as arousing interest in the care of orchards. Further tests of various chemicals for destroying sassafras sprouts were made. Potatoes, tomatoes, onions, and cabbage received attention; average yields of potatoes were 300 bushels per acre as compared with an average yield of 68 bushels per acre for the State.

Cooperative work was carried on by several departments with different bureaus of this Department. The pathologist and veterinarian cooperated with the Bureau of Animal Industry in hog vaccination and tick eradication; the entomologist cooperated with the Bureau of Entomology in studies of the life history of the cattle tick; while the horticulturist continued to cooperate with the Bureau of Plant Industry in growing Hungarian varieties of apples. Considerable cooperative work was done with farmers by the veterinary, dairy, and horticultural departments.

Extension work was carried on by several departments by means of farmers' institutes, addresses at other meetings of farmers, and articles in the press.

The following publications were received from this station during the past year: Bulletins 96, Anthrax in Arkansas; 97, Anthrax and anthrax vaccines; 98, Rice; 99, Farm poultry; and 100, Meteorological summary; and the Annual Report for 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	[a]35,152.97
Farm products, including balance from previous year	2,396.06
Dairy sales	8,337.11
Total	69,886.14

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

Since the close of the fiscal year the director has resigned and has been succeeded by C. F. Adams, the entomologist of the station, as acting director.

CALIFORNIA.

Agricultural Experiment Station of the University of California, *Berkeley.*

E. J. Wickson, A. M., *Director.*

As in previous years, the work of the California Station proceeded along a large number of lines in response to the needs of the extensive and varied agricultural interests of the State. Elwood Mead, irrigation engineer, was granted leave of absence during the year to take charge of irrigation work for the Australian government. F. T. Bioletti resigned as viticulturist. At the end of the year Leroy Anderson was appointed professor of dairy industry, with H. A. Hopper, of the Indiana Station, as assistant professor, and E. H. Hageman in charge of dairy manufacture; E. W. Major is to devote himself entirely to the work in animal industry; T. F. Hunt was made superintendent of the Riverside Station, vice J. W. Mills, resigned; a number of assistants were appointed in the department of entomology.

The work on projects supported wholly or in part from the Adams fund was continued during the year and sufficient progress was made in several instances to warrant publication of results; thus Circular 27 is in the nature of a progress report on the investigation into the occurrence of chlorosis on citrus trees in the Porterville region and its relation to marly subsoils, while Bulletin 188 gives the results of experiments to test the efficiency of ditch and reservoir linings to prevent seepage losses, and Bulletin 191 is a report on California peach blight.

The chief lines of work aside from Adams fund projects were as follows: Soil studies as suggested by special manifestations of injury to growing crops, also of soils of regions needed to advance the soil survey of the State. An extension of the work of demonstrating

[a] For two years, ending June 30, 1909.

relative toleration of different plants for alkali in the soil was also made. Cereal investigations were continued to determine relative productiveness of varieties, the gluten content of wheats and the brewing suitability of barleys, the effects of various amounts of moisture and different temperatures upon gluten content of wheat, and the effects of rotation with legumes and other plants. Plant breeding of wheats on the centgener plan and crossing of wheats with a view of securing superior local adaptations were both carried on to a large extent. Investigations were instituted into the occurrence of bacterial blight of the English walnut, the relative resistance of individual trees in large areas of seedling orchards, and the success of different methods of grafting and budding with scions from resistant trees and the trial of various rootstocks for the English walnut. Large field experiments in spraying for the tomato blight and the celery rust were made. Experiments were carried on with various fertilizing, cultivating, and irrigation methods and policies upon areas of bearing orange trees leased for the purpose, as correlated with applications and treatment of experiment plats in the station orchards. A systematic study was undertaken of Eucalyptus species which had attained considerable age on the station grounds and in private plantings in various parts of the State. Field studies of vineyard insects and experiments in their repression were made. Extended observations were continued on the occurrence of bovine tuberculosis and the operation of the tuberculin test; and cow testing in a number of herds, with a study of environment, care, and feeding in connection with milk yield, was carried on. Investigation of the honey industry, the relative value of bee forage plants, and the occurrence of bee diseases were studied. Local study of the olive tuberculosis and the methods of its distribution was undertaken.

Various buildings and other permanent improvements to the amount of about $50,000 were secured during the year 1907–8 on the university farm at Davis, and these, according to the law, are to be used both for instruction and experiment, and were designed with such ends in view.

A laboratory and other buildings were finished in southern California at a cost of $12,000, and a new fertilizer-control laboratory was constructed at the station, costing $10,000 for building and equipment. (Pl. I, fig. 1.)

Nearly all the station investigators cooperated with farmers, each in his own line, for the purpose of demonstrating results of work in laboratory or trial grounds. Cooperative work was also carried on in the cereal investigations with the Bureau of Plant Industry of this Department.

Six bulletins and eleven circulars were received from this station during the fiscal year, as follows: Bulletins 188, Lining of ditches

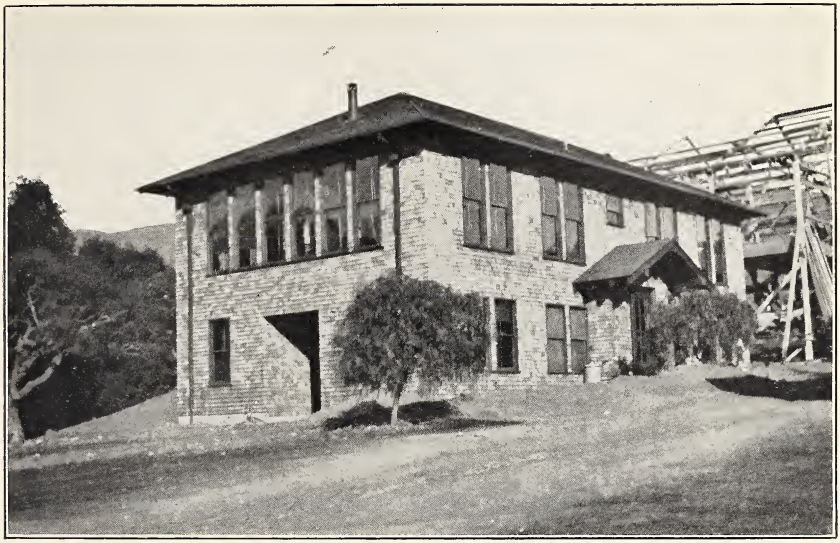

FIG. 1.—FERTILIZER-CONTROL LABORATORY, CALIFORNIA STATION.

FIG. 2.—INSECTARY AND CONSERVATORY, KENTUCKY STATION.

and reservoirs to prevent seepage losses; 189, Commercial fertilizers; 190, The brown rot of the lemon; 191, California peach blight; 192, Insects injurious to the vine in California; 193, The best wine grapes for California.—Pruning young vines.—Pruning the Sultanina; and 194, Commercial fertilizers; Circulars 25, Suggestions regarding the examination of lands; 26, Selection and preparation of vine cuttings; 27, Marly subsoils and the chlorosis or yellowing of citrus trees; 28, A preliminary progress report of cereal investigations, 1905–1907; 30, White fly in California; 31, The agricultural college and its relationship to the scheme of National education; 32, White fly eradication; 33, Packing prunes in cans.—Cane sugar versus beet sugar; 34, California State farmers' institute at the university farm, Davisville; 36, Analysis of fertilizers for consumers; and 37, Instruction in practical agriculture upon the university farm at Davis, Cal.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation, including balance from previous year	121,317.22
Local community (balance from previous year)	366.06
Fees	8,306.38
Balance from previous year	6,210.60
Farm products, including balance from previous year	9,067.41
Miscellaneous	38,252.65
Total	207,520.32

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The work of the California Station has materially increased in scope and importance during the past year, and is yielding results which are largely modifying agricultural practice in the State.

COLORADO.

Agricultural Experiment Station, *Fort Collins.*

Department of the State Agricultural College of Colorado.

L. G. Carpenter, M. S., *Director.*

The work of the year at the Colorado Station was along the general lines laid down in the previous year's report. W. G. Sackett, of the Michigan College and Station, was added to the staff as bacteriologist; since the end of the fiscal year W. L. Carlyle has resigned and been succeeded by C. W. Gay, formerly professor of animal husbandry in the Veterinary College of the University of

Pennsylvania, while Alvin Keyser, in charge of the soils work at the Nebraska University and Station, has been appointed agronomist, vice W. H. Olin.

Work was continued on the Adams fund projects previously outlined, and definite results were obtained in some cases; no new projects were started. The study of alfalfa disease indicated that it may be possible to obtain varieties that are immune; the cause of the disease was determined and material progress made in an attempt to neutralize the effect. The work on plant lice progressed and two bulletins on the subject have been published since the close of the fiscal year. The saltbush investigation was completed with regard to its value as a forage plant.

Besides the Adams fund projects, work was done along the following lines: Potato investigations, including potato diseases; studies of special horticultural interests; feeding experiments with steers and swine; study of concrete fence posts; relation of forests to water supply; codling moth studies; the causation of the loco disease; and investigation of alkali questions, including as a subsidiary question the effect of arsenic when used as a spray in localities having alkali soils. The results of this phase of the investigation have been published and seem to show that excessive spraying in alkali districts may materially injure fruit trees or even cause the death of the orchard. Only a small amount of cooperative work was undertaken, dealing mainly with the varying climatic conditions found in different sections of the State. The loco investigation was carried on in cooperation with the Bureau of Plant Industry of this Department.

The extension work of the station may be specially classed as work on potatoes and fruit investigations. The former is maintained principally by appropriations from the State board of agriculture, the station contributing a small amount. This work is partly experimental but more largely educational. For the former purpose a small tract of land was used for experimental purposes near Greeley, and a special man employed to give almost his entire time to studying the potato interests of the State. There has been a large increase in potato growing on the western slope. Two men were employed in fruit work in the western part of the State. The station men also took part in farmers' institutes and short courses in various parts of the State.

The following publications were received from this station during the fiscal year: Bulletins 120, The Howard scale; 123, The plains, some press bulletins; 124, Colorado fodders, an examination into their composition and comparative values; 125, Colorado fodders, a study of comparative values; 126, Cantaloup breeding; 127, Climate of Colorado, temperature, twenty-one years' record at Fort Collins;

128, Alfalfa studies, progress report; 129, Extraction of beeswax; 130, The evergreen trees of Colorado.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	8,756.22
Balance from previous year, Adams Act	243.78
State appropriation	27,500.00
Special fund, including balance from previous year	13,479.58
Total	64,979.58

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Colorado Station has a broad field, and, with the increasing support which it is receiving, will be able to do good work along several lines of especial importance to its own and neighboring States.

CONNECTICUT.

The Connecticut Agricultural Experiment Station, *New Haven.*

E. H. JENKINS, Ph. D., *Director.*

The Connecticut State Station has made few changes in its personnel or lines of work. Good progress was made on the Adams fund projects under way and the number was enlarged to include breeding experiments with tobacco and researches on the composition, constitution, and properties of proteids, especially those of ripe seeds. The project on the proteids will embrace a portion of the comprehensive investigations which have been maintained for several years under grants from the Carnegie Institution.

A study of the factors entering into the improvement of the potato, the relation of chemical and physical characters to quality, and the amount of fluctuations of these characters, begun by the agronomist when at the University of Illinois, has been completed and the results published. Studies have been continued of potato blight, the calico disease of tobacco, and certain peridermia of economic importance. Experiments with tomatoes are in progress to determine whether, by abnormal treatment of the developing seed, it is possible to change in any way the usual characters of the offspring, a question of great economic importance. A somewhat extensive cooperative experiment has also been begun with a melon grower of the State.

The station has finished a complete forest survey of three counties, and is giving increased attention to other phases of forestry work in which much interest is being developed in the State. It is

estimated that 600,000 trees were planted by private landowners during the past year, as compared with 350,000 and 100,000 for the two previous years. Farmers in many sections are now marketing their wood by improvement cuttings planned by the station forester. The work of forest-fire wardens has been made more effective, and a better public sentiment has been brought about regarding forest fires.

The station staff participated in about 100 farmers' institutes, which have constituted the chief form of extension work undertaken. The State inspection and control work required of the station continues to be very heavy and now includes the analysis of fertilizers, foods and feeding stuffs, and the inspection of nurseries. A systematic examination of seeds has also been undertaken, an assistant being appointed whose whole time is devoted to this work. Considerable benefit to farmers has resulted from this examination, especially in the purchase of clover seed. An aggressive campaign has been continued against the gipsy moth, with the result that the area of the infested territory has been considerably reduced.

During the year the station issued several publications of a popular nature under the name of Bulletins of Immediate Information, and it has recently inaugurated a series known as "Postal Card Bulletins." These are similar in form, size, and appearance to ordinary postal cards and present brief notes of a popular nature. In order to comply with the State law providing for biennial reports from State institutions, the station reports for 1907 are being issued as parts of a biennial report for 1907–8, those portions received during the fiscal year being parts 1–3, devoted to the results of the examination of fertilizers, food products, and commercial feeding stuffs, and parts 4–7 to the reports of the forester, entomologist, botanist, and agronomist. Other publications received during the fiscal year included Bulletins 156, Cotton-seed meal as a fertilizer; 157, Lead arsenate and Paris green; 158, The relation of certain biological principles to plant breeding; 159, Spray calendar; 160, Clover seed in the Connecticut market; and Part 6 of the Annual Report for 1906, devoted to the report of the forester.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$7,500.00
United States appropriation, Adams Act	4,500.00
State appropriations	19,000.00
Individuals	9,847.40
Fees	7,607.77
Farm products	279.02
Miscellaneous	351.06
Total	49,085.25

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The work of the Connecticut State Station is being steadily prosecuted, with results of considerable economic value to the agriculture of the State. The studies on proteids have reached a point where the results are being generally recognized as having an important and fundamental bearing on the theory and practice of animal nutrition.

Storrs Agricultural Experiment Station, *Storrs.*

Department of the Connecticut Agricultural College.

L. A. Clinton, M. S., *Director.*

At the Connecticut Storrs Station the lines of work already under way were strengthened and enlarged, but it was not thought wise to undertake new lines of investigation.

The most important results of the last year's work were under the Adams fund, along the lines of dairy bacteriology and investigations in soft-cheese manufacture. In the bacteriological work special attention was given to the sources of bacteria in milk, as, for example, hay, bedding, and contamination from the cow herself. In soft-cheese investigations the Roquefort type of cheese was most carefully studied. The Camembert type has been so completely studied that it is now possible to manufacture a uniformly high quality of this type of cheese. The soft-cheese investigations were carried on in cooperation with the Dairy Division of this Department.

The main lines of work carried on with other funds were poultry and dairy investigations.

In cooperation with the farmers of the State, spraying experiments were conducted. These relate especially to the control of the San José scale. A new spray mixture was discovered by the horticulturist of the station, and this proved very efficient in controlling San José scale.

No extension work was attempted by the station, as the State had provided no appropriation for the purpose.

Since the close of the fiscal year G. H. Lamson, jr., instructor in the college, has been appointed entomologist in the station; F. H. Stoneburn, formerly connected with the poultry work of the college and station, has been appointed poultryman, vice C. K. Graham, resigned; Clinton Grant has been appointed cheese maker in the cooperative experiments with the Dairy Division of this Department in place of F. R. Thompson, resigned.

The publications received from the station during the fiscal year were as follows: Bulletins 47, Milking machines. Part I. Effect

upon quality of milk. Part II. Effect upon milk yield; 48, Comparative studies with covered milk pails; 49, Petroleum emulsion for the San José scale; 50, Squab investigations; and 51, Sources of bacteria in milk.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$7,500.00
United States appropriation, Adams Act	4,500.00
State appropriation	1,800.00
Balance from previous year	151.09
Miscellaneous, including balance from previous year	610.61
Total	14,561.70

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The character of the work done at the Storrs Station indicates the wisdom of concentrated and continuous effort along a few important lines.

DELAWARE.

The Delaware College Agricultural Experiment Station, *Newark.*

Department of Delaware College.

H. HAYWARD, M. S. Agr., *Director.*

The year at the Delaware Station has been largely a formative period consequent upon the numerous changes in personnel and policy of the year preceding. Considerable progress was attained in the development of the new farm. This is managed entirely as a station enterprise, although college funds have been used in the purchase of a portion of the live stock. Aside from 5 acres devoted to buildings and yards and 32 acres to a wood lot, the entire area is to be utilized for experimental purposes, 25 acres being assigned to agronomy, 37 acres to horticulture, and the remainder, 113 acres, to animal husbandry experiments. It is expected that some revenue will accrue to the station from the sale of farm crops and other produce. New barns and sheds are urgently required, and it is hoped to secure a State appropriation for their erection.

The work prosecuted under the Adams Act during the past year included studies of anthrax, with a view to finding a single vaccine and a serum for treating animals already infected; the functions of tannin in plants; the "double blossom" disease of the genus Rubus; the functions of fertilizers in the production of peaches and apples; and the laws controlling the rate of assimilation of nitrogen by crimson clover. In connection with this work additional equipment has been obtained for the laboratories of the plant pathologist, veteri-

narian, and chemist. For the horticultural project on fertilizers for peaches and apples, a considerable number of large concrete pits are being constructed and so arranged that the drainage water from them can be examined.

Aside from the projects under the Adams Act a large number of fertilizer, variety, and cultural tests are now under way, especially with wheat, oats, corn, soy beans, cowpeas, crimson clover, tomatoes, grasses, peaches, and potatoes. The work with corn includes experiments in the adaptation of the cultural methods of the Middle West to Delaware conditions, a trial of the ear-row method of selecting seed corn as a preliminary to corn breeding, and 30 cooperative experiments with varieties of corn in different parts of the State. There is some cooperative work with alfalfa and demonstration trials with grasses of different kinds, alfalfa, and crimson clover.

The entomologist is studying means of control of southern corn rootworm, corn root aphis, and striped spot beetle. Cooperative spraying experiments have been carried on by the horticulturist in the lower part of the State.

The position of chemist was vacant during the year, but has been filled by the appointment of Firman Thompson, who entered upon his duties July 1, 1908. A report of investigations on miscible oils was prepared by the former chemist and issued as a bulletin of the station.

The station is endeavoring to get into closer touch with the people of the State. Members of the staff have participated, to a limited extent, in farmers' institutes and meetings of other organizations. such as the Federation of Women's Clubs, the Woman's Christian Temperance Union, Pomona Granges, and other bodies. An attendance of 40 persons was secured at the short winter course at the college.

The publications received from the station during the fiscal year included Bulletins 78, The effect of desiccation on root-tubercle bacteria; 79, Home-made miscible oils—Orchard tests of miscible oils; 80, Annual report of the Director; 81, Report of the agronomist for the season 1907; and the Annual Reports for 1904, 1905, and 1906.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Farm products	1,475.59
Miscellaneous	62.50
Total	25,538.09

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The work of the Delaware Station is being organized on a broader plan than hitherto, and a number of useful enterprises have been inaugurated. The State has made a notable contribution to the equipment of the station by giving land for experimental purposes, and if this is followed up by provision for buildings and maintenance, experiments with plants and animals may be conducted on an effective scale.

FLORIDA.

Agricultural Experiment Station of Florida, ***Gainesville.***

Department of the University of the State of Florida.

P. H. Rolfs, M. S., *Director.*

This station has made marked progress in organizing and equiping its work in its new location. Experimental field and horticultural plats have been systematically laid out and planted, and feeding stalls, pens, and pastures (about 180 acres) have been provided. Fairly satisfactory office and laboratory facilities are now available. The experimental farm plats occupy 58 acres, mainly on typical pine woods land. The horticultural grounds occupy about 50 acres of hammock land, about 6 acres of this being provided with a system of overhead piping for irrigation by sprinkling. A pumping plant to supply the necessary water has been installed.

After the close of the year covered by this report an agronomist, J. J. Vernon, formerly of the New Mexico Station; an assistant plant pathologist, Thomas Hamilton; and an assistant entomologist, E. P. Greene, were added to the station staff.

The director continues to have charge of farmers' institutes, which are now very successful. The extensive cooperative work of the station in different parts of the State has been continued and enlarged. As a report of the director points out, the work of this station is developing "unconsciously rather than by design into a method of projects rather than of departments. The advantages accruing from this rather unconscious development will very readily be understood when we remember that the crop production of Florida is more variable than that of any other State in the Union, reaching from the tropical fruits in the South to the production of corn and grain in the West. Another feature that has accentuated this line of investigation is that Florida agriculturists are really specialists in many lines. The pineapple and tropical fruit grower in the southern portion of the State needs a very different line of investigation from that which is carried on within the corn, cotton, and sweet potato producing section of the State (northern and western Florida). The citrus groves, on the other hand, demand a treatment very distinct and different from either of these."

The station has undertaken work on a small number of well-chosen Adams fund projects which in the main supplement one another and together really form one large project. This results in very close cooperation between different members of the station staff, continuity of effort, and definiteness and fixity of purpose in scientific work. No new projects were undertaken during the year, but those already in progress were extended in scope and brought to a stage of development warranting partial report of the results. This was done in the case of investigations on acid soils[a] and of fungus diseases of scale insects and white fly.[b] The investigations on acid soils have shown the wide distribution of such soils in Florida and indicated how these soils may be improved by the judicious use of lime. The investigations on fungus diseases of scale insects and white fly have shown that fungus diseases may be successfully used in combating these pests under the favorable climatic conditions of Florida. The practical methods to be employed have been carefully worked out.

Aside from Adams fund work the station has given attention to feeding experiments with beef cattle, dairy cows, and pigs, to determine the relative merits of various Florida feeds; improvement of native cattle by crossing with pure-bred Shorthorns and Herefords; tests of varieties and improvement by breeding and selection of cotton, corn, sweet potatoes, cassava, sweet corn, sorghum, alfalfa, cowpeas, velvet beans, and other forage crops; fertilizer tests with corn, cotton, and pineapples; breeding lettuce resistant to drop and tests of varieties of lettuce; diseases (especially blackheart) and relation of fertilizers and moisture conditions to health of celery; breeding disease-resistant eggplants and tomatoes; comparative tests of various leguminous plants; studies on fertilization of the mango; tests of guavas and pawpaws and their utilization as food; miscellaneous analyses and studies of plant diseases and insects; and nursery inspection.

The publications received from the station during the year were as follows: Bulletins 89, Occurrence and use of artesian and other underground water; 90, Pig feeding with cassava and sweet potatoes; 91, Tomato diseases; 92, Sorghum for silage and forage; and 93, Soil studies II, acid soils; Circular 1; and the Annual Report for 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	8,998.08
Balance from previous year, Adams Act	1.92
State appropriation	1,030.20
Farm products	1,664.74
Miscellaneous, including balance from previous year	240.86
Total	26,935.80

[a] Florida Sta. Bul. 93.

[b] Florida Sta. Bul. 94.

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and have been approved.

The Florida Station continues to make consistent development in organization, equipment, and lines of investigation, and although thrown so recently into new and entirely undeveloped environment, is rapidly being put on a basis for most efficient scientific and practical work.

GEORGIA.

Georgia Experiment Station, *Experiment.*[a]

Department of Georgia State College of Agriculture and Mechanic Arts.

M. V. Calvin, *Director.*

The scope and character of the work of this station were not materially changed during the year, but a number of changes occurred in the personnel, particularly about the end of the year. W. L. Owen, bacteriologist, resigned to accept a position with the Louisiana Experiment Station, and was succeeded by J. C. Temple; R. J. H. De Loach, botanist, resigned to become professor of cotton industry in the agricultural college at Athens, and was succeeded by C. A. McLendon; and T. H. McHatton, horticulturist, resigned to become adjunct professor of horticulture in the agricultural college at Athens, and was succeeded by H. P. Stuckey.

Through the efforts of citizens of Griffin 94 acres of land, consisting mainly of woodland, with a small amount of open land, was added to the station farm. The sugar experiment station at Waycross was turned over to the station during the year, and arrangements were made for its local maintenance and operation.

Work was continued during the year on several of the Adams fund projects enumerated in last year's report, but little or no progress was made in some of these lines of investigation on account of changes in staff or for other reasons. Reports of progress on investigations in nitrification and on Mendelian and De Vriesian evolution of cotton have been made.[b] The investigations on nitrification showed the dependence of this process upon carbonates in the soil, that magnesium carbonate is a better form for this purpose than calcium carbonate, and that the nitrifying organisms do not use the free carbon dioxid of the air. The report on evolution of cotton lays a good foundation for further investigation on this subject. Considerable progress has been made in the fig investigations, particularly in the study of synonymy and nomenclature, but these inves-

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[a] Telegraph, freight, and express address, *Griffin.*

[b] Georgia Sta. Buls. 81 and 83.

tigations were practically suspended, at least for the time being, with the publication of Professor Starnes's last report.[a] The study of the nitrogen balance as a guide in feeding animals was developed as an Adams fund project during the year.

The work of the agriculturist was in the main substantially the same as in previous years. In addition to the usual variety and fertilizer tests on cotton, corn, oats, and wheat, the Williamson method of corn culture, and large and small cotton seed were tested.

In addition to Adams fund work, the animal husbandman studied conditions on certain representative dairy farms in the State in cooperation with the Dairy Division of the Bureau of Animal Industry of this Department and made feeding experiments with hogs and dairy cows.

The dairyman was granted leave of absence during a part of the year to do special work at Cornell University.

The horticulturist gave attention especially to pear-blight remedies, plum wilt, orchard mulching, fertilizers for orchards and for vegetables, shipping of figs, and variety tests of fruits and vegetables.

The year was marked by unusual activity in the line of agricultural education in the State. A "better-farming special" made a 34-day trip over the State during the spring and gave instruction to over 150,000 people on seed selection, fertilizers, care of live stock, orchards, gardening and truck growing, insects, plant diseases, handling and utilizing cotton products, management of the farm, and agricultural education. By legislative act the net proceeds of oil and fertilizer taxes were set aside for the use of the district agricultural schools. The agricultural college at Athens received an appropriation of $105,000.

The following publications were received from this station during the past year: Bulletins 76, Feeding Tennessee steers in Georgia, The outlook for beef production in Georgia; 77, The fig in Georgia; 78, Corn culture; and 79, Cotton culture. Circulars 61, Finishing hogs for market; 62, Plant maladies and their control; 63, Dehorning cattle; 64, Fruits for Georgia; and 65, Variety tests of cotton and corn; and the Annual Reports for 1906 and 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$14,998.00
Balance from previous year, Hatch Act	2.00
United States appropriation, Adams Act	9,000.00
State appropriation	710.10
Farm products	2,099.37
Balance from previous year	1,911.67
Total	28,721.14

[a] Georgia Sta. Bul. 77.

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Georgia Station has encountered many difficulties and made relatively slow progress during the past year. The conditions have not been favorable to permanence of tenure of its staff and the numerous changes of personnel have been a serious hindrance. Until this station has a stronger organization and expert control its outlook will be uncertain.

HAWAII.

Hawaii Agricultural Experiment Station, *Honolulu.*

Under the supervision of A. C. True, Director, Office of Experiment Stations, United States Department of Agriculture.

E. V. Wilcox, Ph. D., *Special Agent in Charge.*

At the close of the fiscal year Jared G. Smith, who had been in charge of the station since its establishment, resigned to enter into private business, and he was succeeded by E. V. Wilcox, who for a number of years had been connected with the Office of Experiment Stations. C. E. Hunn, a graduate of Cornell University, was added to the staff as assistant horticulturist and entered upon his duties in February, 1908. Considerable work has been expended on the grounds and buildings. A number of temporary buildings have been removed, and from the material a tool house and a fertilizer shed were erected. The water system has been extended and more than a mile of fence erected to surround the experimental grounds. The orchard plantings have been extended both on the upper and lower portions of the station, more than 200 trees having been added to the collections during the year. The banana collection, which consists of about forty varieties, has been moved to a more sheltered place, the situation near the office proving unsuited to proper banana culture, on account of the action of the winds. The leases held at Hilo for cacao and banana culture have been terminated on account of the difficulty of supervising experiments at such a distance.

The principal chemical work for the year was analytical, and for the larger part consisted of determinations of the composition of paddy, rice straw, and rice grain. The analyses showed that the claim that imported Japan rice is more nutritious than Hawaiian-grown rice is not well founded. As a matter of fact, some analyses showed that Hawaiian-grown varieties of Japan rice are more nutritious than the same varieties imported from Japan. It was further found that dry-land rice takes up more lime and less phosphoric acid than submerged rice. Analyses of drainage water from lysimeter

tests showed that the use of ammonium sulphate as a fertilizer for rice causes a loss of lime in the soil.

The rubber experiments have been continued, planting, fertilizer, and tapping experiments being in progress.

The entomologist devoted considerable time to investigations of problems relating to bee raising and honey production. A survey was made of the cattle ranges to determine the present status of the horn-fly. It is reported that sheep breeders have suffered great loss through attacks of the sheep maggot fly, and this pest is being studied. The injurious insects of pineapples, cotton, and mangoes are being collected and means for their repression worked out.

In horticulture the chief work has been on a study of some of the problems of shipping fresh fruit. Several tons of pineapples, avocados, and papaias were prepared for shipment and accompanied to the coast by the horticulturist. As a result of these investigations, it has been demonstrated that pineapples can be readily shipped from Hawaii to any point within thirty days' direct communication with Honolulu.

On the station grounds attention has been given to orchard-cover crops, the crops used being cowpeas, pigeon peas, and jack beans. Experiments with rough lemon as a stock for grafting and budding citrus trees have shown that it is excellently adapted to that purpose, and extensive budding operations are in progress. Budding experiments with mangoes have resulted in the setting of 81 per cent of the buds of the variety Alphonse. With other varieties budding has not been quite so successful. It has been shown that in order to succeed the budding must be done in the early part of the period of active growth. Notes are being taken on the date of flowering of the mango, the period seeming to vary from year to year.

The interest in the rice experiments continues and some definite results have been obtained. Several varieties have been originated or developed by selection that are superior to those in common cultivation. Extensive fertilizer experiments with rice have been carried on, and it has been found that when fertilizers are applied to a rice crop two-thirds grown the first crop receives the least benefit and the second the most, through the residual effect of the fertilizer. If, on the other hand, the fertilizer is applied before planting, it is practically all taken up by the succeeding crop, the residual amount remaining for the second crop being virtually nothing. When only the immediate effect of the fertilizer was considered, ammonium sulphate doubled the yield over unfertilized rice and gave much better results than either lime nitrogen or sodium nitrate. In the culture of dry-land rice, potassium muriate gave striking results. A test was made of salt-marsh rice for hay, and it was found to yield a superior grain

hay that was readily eaten by stock. The experiments with matting rushes and sedges have been continued. Soy beans and peanuts have been grown with satisfactory results, and it is believed that the home market can be readily supplied instead of having to import them as at present. For a number of years the station has carried on tests of varieties of cotton, and as a result of the fine quality of fiber produced considerable attention is being given to this crop as one possibly adapted to the region lying immediately above the cane fields.

The publications of the station during the year, in addition to the Annual Report, were Bulletins 14, Marketing Hawaiian fruits; 15, Cultivation of tobacco in Hawaii; 16, The Ceara rubber tree in Hawaii; 17, Hawaiian honeys; and Press Bulletin 20, The introduction of top minnows into the Hawaiian Islands.

The revenues of the Hawaii Station for the fiscal year ended June 30, 1908, were as follows:

United States appropriation	\$24,000.00
Farm products	750.32
Total	24,750.32

The Hawaii Station has continued its policy of diversification of agriculture and is attempting to concentrate on a few of the larger problems in order that they may be thoroughly worked out before others are taken up. It has been recently stated that at least \$2,000,000 are annually sent out of the islands for products that could and should be raised at home, and the station is being looked to as a source of information regarding the conditions and practices necessary to supply this demand.

Hawaiian Sugar Planters' Experiment Station, *Honolulu.*

C. F. Eckart,[a] M. S., *Director of Division of Agriculture and Chemistry.*

The division of agriculture and chemistry has continued its studies as formerly in the domain of the agriculture of the sugar cane, and in questions relating to sugarhouse technology. The greater part of the field work has been devoted to the selection and propagation of selected varieties of seedling canes, and of these new varieties over 300 have been distributed among the plantations for trial under the varied conditions of soil and climate to be found in the islands. It is not hoped that any but a very small percentage of these will be eventually found suitable as sugar producers, but even one valuable cane will well repay the work of the experiment station.

Experiments dealing with fertilization and with the effect of "stripping," i. e., removing the dead leaves of the cane, have been carried out at substations situated on plantations; in these substa-

[a] On leave.

tions the plantation authorities have collaborated with the officers of the experiment station.

Considerably greater success attended the efforts to secure hybrid seedling canes by cross-pollination in 1907 than in 1906. Altogether 83 hybrids survived and were planted out at the experiment station. These will be allowed to grow until the spring of 1909, and will then be tested.

The staff of this division has been increased by the appointment of Mr. W. E. Burke, succeeded by Mr. F. T. Dillingham, as fifth assistant chemist, and by Mr. J. H. Wale, as substation assistant.

The division of entomology has continued its work on cane leaf hopper and its parasites. The leaf hopper is now well under control on all the plantations, almost entirely as the result of the work of introduced parasites. The agricultural methods of the plantations render the continued restocking of young cane fields a necessity. The usual inspection of plantations by the entomological staff has been carried out.

The traveling entomologist has visited Borneo and various islands to the east in search of the Hawaiian cane borer and possible parasites. The cane borer was first discovered in Larat, and later in Amboina. Predaceous beetles were found attacking the borer, and one of these has been successfully introduced. A parasitic fly was also found in Amboina which destroyed the borer larvæ. Through the courtesy of the Agricultural Department at Hongkong, a temporary halfway station has been established there, in charge of one of the assistant entomologists of this station. This was found a necessity on account of the long distance and changes of climate between the Malays and Hawaii. The life histories of the predators and parasites will be studied and attempts made to introduce them.

In the division of pathology and physiology Dr. H. L. Lyon and L. R. Larsen have been appointed assistant pathologists. Root diseases have continued to receive attention, and the relative importance of each is becoming better known; the soil treatment recommended by the division is adopted by many plantations, apparently with success. "Pineapple" disease has again been the subject of experiment, and its prevention by treatment with Bordeaux mixture is well established. An increasing number of plantations are adopting this treatment with beneficial results.

Among new lines of work begun during the year may be mentioned an investigation of a forest disease on the island of Maui. The disease would appear to be due to a root fungus, the nature of which is under investigation.

A research on the bacteria of raw sugars is being carried on by this division, collaborating with the division of agriculture and chemistry; this work is in connection with the deterioration of stored

sugars. All the bacteria found commonly on Hawaiian sugars will be investigated separately, and their effect on raw sugars studied experimentally.

The minute structure and development of the cane flower and seed are being thoroughly worked out. This work is rendered most difficult by the great sterility of the flowers, less than 1 per cent, even in the most fertile varieties, of the flowers producing seeds.

A regular inspection of plantations by the assistant pathologists is planned. The necessity for the thorough inspection of every plantation is rendered more imperative than before by the introduction of many new varieties of cane on nearly all the plantations.

The following bulletins of the station were received during the year: Division of agriculture and chemistry, Bulletins 20, A theory of the extraction of sugar from massecuites; 21, Evaporator scale; 22, A theory of the extraction of juice by milling; 23, Use of formaldehyde solution in sugar mills; 24, The deterioration of sugars on storage; 25, Results from stripping experiments; and 26, Varieties of cane, with special reference to nomenclature; division of entomology, Bulletins 3, Leaf-hoppers—supplement, and 5, The sugar-cane leaf-roller; and an index to volume 2, comprising Bulletins 2–5; division of pathology and physiology, Bulletin 8, Red rot of the sugar-cane stem.

This station receives no direct aid from the Federal appropriations.

C. F. Eckart, director of the division of agriculture and chemistry and business director of the station, has been given a year's leave of absence, during which Noël Deerr will act as director of the division of agriculture and chemistry and L. Lewton-Brain as business director.

IDAHO.

Agricultural Experiment Station of the University of Idaho, ***Moscow.***

Department of the University of Idaho.

H. T. French, M. S., *Director.*

The Idaho Station is still suffering from the congested condition due to the destruction of the main building of the university in 1906. The crowded condition in Morrill Hall has not permitted the desirable equipment of laboratories, and only those of the chemist and the dairy department are at all adequate. The greenhouses and horticultural laboratory removed or occupied by the university have not been replaced, but a greenhouse for soil fertility, plant breeding, and horticultural investigations is soon to be erected by the university for the use of the station staff.

Considerable progress has been made in all the lines of work taken up under the Adams Act. No new projects have been undertaken,

the list of approved projects being the same as that given in the report for 1907. A partial failure was reported in the apple-breeding experiments, due to unfavorable weather at the time of pollination, but some seedlings have been secured and are being propagated. In the study of the gluten content of wheat there have been developed some interesting facts relating to the influence of soils, fertilizers, and irrigation. The utilization of orchard by-products has been largely a study of cider fermentation, pasteurization, etc. The project on the duty of water in summer, winter, and fall irrigation is being given much attention, and results of great scientific interest and practical importance are expected. Interesting data are already at hand on the conservation of soil moisture, which can not fail to be of benefit to agriculture in the arid regions.

In the dairy department tests are being made of the moisture content of butter and the alleged shrinking of butter under commercial conditions. Attempts are being made to arouse interest in dairying through organizations and cooperative investigations.

In horticulture, cooperative work is being conducted on 10 acres near Moscow in spraying for the prevention of apple scab. Two forms of lime and sulphur were used, one a trade compound and the other a self-boiled mixture, comparisons being made with Bordeaux mixture. Both forms of the lime-sulphur mixture proved quite efficient, and there was no burning or russeting of the fruit, as was the case where Bordeaux mixture was used. Special forms of dust sprays are being tested, and experiments for the control of the codling moth are under way. These consist of comparisons of a dust spray, Paris green, and a solution of arsenate of lead. These experiments are conducted near a well-traveled road and are well known and favorably commented on by passers-by. The horticulturist conducted some experiments the past season that demonstrated the commercial possibilities of tomato growing, tested the effect of pruning tomatoes on the earliness and productivity of the plants, and tested seed flats versus pots for starting tomato plants. In the orchards he is testing summer pruning, dwarf fruit trees for Idaho conditions, and cover crops.

The chemist has been making a large number of analyses of typical soils. He also made a number of water analyses, especially of irrigation waters, and is studying the mineral constituents of orchard fruits, composition of local feeding stuffs, and alcohol production from sugar beets and potatoes.

In agronomy the principal work has been on variety testing and rotation and fertilizer experiments with potatoes, wheat, oats, and corn. Breeding experiments with wheat and oats are being carried on.

In animal husbandry, feeding experiments with dairy cows to determine cost of production of butter fat, wintering pigs, and pig breeding constitute the main lines of investigation.

The station is doing considerable demonstration work in orcharding, spraying, use of lime on acid soils near Coeur d'Alene, and drainage for removal of alkali in overirrigated lands.

The station has rendered service at farmers' institutes and in the early summer a demonstration train in charge of the station was run over the Northern Pacific Railroad in Idaho. It was a great success and more work of this kind is planned.

Three bulletins have been received from this station during the year, as follows: Bulletins 57, Indian corn, its production and improvement; 58, Irrigation investigations; and 59, A soil fertility test.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Farm products	1,671.38
Balance from previous year	328.68
Total	26,058.06

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Idaho Station is making a creditable showing in the face of adverse conditions, but it can not be expected to develop its full usefulness until adequate facilities and equipment are provided.

ILLINOIS.

Agricultural Experiment Station of the University of Illinois, *Urbana.*

Department of the University of Illinois.

EUGENE DAVENPORT, M. Agr., *Director.*

A new building for floriculture investigations has been erected during the past year at the Illinois Station. It consists of two large greenhouses, each 105 by 28 feet, with rooms for offices, storage, heating plant, etc. The building cost $14,000, and is so arranged that the glasshouse area can be extended as the need arises. It is planned to carry on extensive fertilizer experiments with carnations; the work in floriculture is in charge of Mr. H. B. Dorner.

Work under the Adams fund in the four lines of investigation announced in our report for 1907 has made good progress during the past year. To these has been added a chemical and physiological study of the effects of different amounts of the same feeds on digestion and utilization in maintenance, growth, and fattening of animals. A beginning has been undertaken with steers, and very careful and

elaborate arrangements have been made to secure thoroughness and accuracy of results. The investigations are being quite strictly limited in scope, and wherever thoroughness demands other funds of the station are being drawn upon as far as possible.

The soil survey is steadily progressing with the State appropriation of $25,000 annually. During the past year the soils of four additional counties have been studied. Twenty-eight counties have now been covered and mapped. These are so distributed that there is now no county which has not a surveyed county adjoining it. Soil analyses and pot cultures have been made, twenty-five experimental fields of from 10 to 40 acres have been established in different parts of the State, and the whole work has been planned with reference to increasing fertility. On these fields generally two systems of farming are compared—grain farming and live-stock husbandry. There are some crop-production fields where varieties, methods of culture, etc., are tested with reference to local conditions. An advisory committee goes to the fields at least once a year, and meetings of farmers are held there. In this way information regarding the work is widely distributed. Members of the committee serve without salary, but have their traveling expenses paid. From the soil investigations the State is acquiring a fuller, definite knowledge of the peculiarities of its different types of soils, and a sufficient proportion of farmers are beginning to utilize the method to visibly affect the yields of crops. It is regarded as especially gratifying in connection with the wheat area of southern Illinois, which ten years ago ranked with some of the poorer States, but now has an average of the last three years ranking equally with Indiana, Ohio, and Pennsylvania, which are the highest yields of the country. This increase of yield of approximately 5 bushels per acre in the last ten years is attributed to the general use of the methods advocated by the station.

In chemistry a very extensive study of saltpeter as a meat preservative has been made, in which 24 men were fed for a period of nine months and chemical determinations made.

The horticulturist has carried on work along a number of lines, some of which are not sufficiently developed to give definite results. It has been established that adequate greenhouse facilities are of prime importance in breeding experiments with flowers. Spraying experiments at various points in the State with various proprietary mixtures have demonstrated the fact that weather conditions have a great deal to do with the efficiency of these mixtures. From experiments with artificial shade in growing different vegetables, it appears that differences in moisture are more important than those of temperature.

The dairy department is actively engaged in numerous investigations looking to the promotion of this important industry. A com-

parison of alfalfa and timothy hay as a feed for dairy cattle has been made, the results showing the usefulness of alfalfa and giving a difference in value of about $8 per ton in favor of alfalfa. Studies have been made of the composition of butter and of the effect of the pasteurization of milk for butter making. A new method of working butter to secure uniformity in salt content has been devised, and the butter makers of the State are adopting it.

The principal extension work of the Illinois College and Station is through the farmers' institute management and addresses at the meeting of State and other associations. It is the custom to have two speakers at each one of the 102 county institutes, and each department is well represented at the State meetings of those associations coming nearest to its line of work, such as the State Institute, the State Live Stock Breeders' Association, State Horticultural Society, State Dairymen's Association, State Florists' Association, etc. Certain lines of work are also represented on special trains run by the various railroads of the State. Another form of extension work is in the occasional meeting with a local farmers' club or other local associations of the nature of civic improvement. A call occasionally comes to address a chamber of commerce or at least such portion of it as is interested in agriculture. Such calls for special information are rapidly increasing.

Extension work was also done at Chautauquas, and at four special camp meetings for farmers and their families held for a week each. The money for these meetings was subscribed by local parties. Such subjects as stock judging, soil testing, and domestic science were taught. Special attention was given to boys. Three men from the university were at work all summer at these outside meetings.

A special effort is being made to get into close touch with teachers in high schools with a view to stimulating the introduction of agriculture in such schools. An increased number of teachers are becoming interested in this work and are seeking information and materials for instruction from the agricultural college.

President James, of the university, has been abroad during the summer making a special study of European veterinary schools. It is planned to establish a high-grade veterinary school in Chicago under the direction of the University of Illinois. It is the policy at the university to afford members of the faculty opportunities for advanced study, and leaves of absence are granted for this purpose. A number of men connected with the agricultural college have already availed themselves of this privilege, and others are planning to do so.

During the fiscal year 10 bulletins, 7 circulars, and the Annual Report for 1907 were received from the Illinois Station. The numbers and subjects of the bulletins and circulars were as follows: Bulletins 116, On the life history, habits, and economic relations of the

white grubs and May beetles; 117, Bitter rot of apples—horticultural investigations; 118, Bitter rot of apples—botanical investigations; 119, Type and variability in corn; 120, Milk supply of Chicago and twenty-six other cities; 121, Variety tests of wheat; 122, Market classes and grades of horses and mules; 123, The fertility in Illinois soils; 124, Marketing the muskmelon; and 125, Thirty years of crop rotations on the common prairie soil of Illinois; Circulars 111, National association of dairy institute instructors and investigators; 112, Control of bitter rot of apples; 113, Maple spring dairy; 114, The problem of the poor cow; 115, Why and how to test dairy cows; 116, Phosphorus and humus in relation to Illinois soils; and 117, Dry rot of corn.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	8,864.38
Balance from previous year, Adams Act	135.62
State appropriation	102,500.00
Farm products	13,430.97
Balance from previous year	21,201.93
Total	161,132.90

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Illinois Station is doing more careful and systematic work than ever before, and is coming into closer touch with the agricultural people throughout the State. The cordial appreciation of the station's work is shown by the very generous State appropriation.

INDIANA.

Agricultural Experiment Station of Indiana, ***Lafayette.***

Department of Purdue University.

Arthur Goss, M. S., A. C., *Director.*

The policy and enterprises of the Indiana Station were much the same as heretofore. The general business of the director's office greatly increased, and temporarily much work was caused by the erection of the new building, provision for which was reported in 1907. This building has recently been completed. It is of fire proof construction and very substantially built, and is the largest building in the United States exclusively devoted to experiment station work.

Under the Adams Act work was continued in the four lines reported in 1907. The investigation of rust was actively prosecuted and a large amount of material and data were collected from different

parts of the country. The life histories of a number of species were worked out. The work on hog cholera was along lines approved by the conference of Department and station veterinarians held at Ames, Iowa. The virulence of different strains of virus is being determined, and studies are being made regarding the actual relation of the hog-cholera bacillus to the disease. In the investigation of the moisture content of butter, examinations, including a large number of fat analyses, were made of all the butter made in the college creamery. The fats were churned separately and the moisture content noted in its relation to the nature of the fat. The effects of different churns, size of churning, temperature of cream, size of fat granules, and similar factors were determined.

In the department of agronomy the results of rotation and other plat experiments on the station farm, which have been running about twenty years, are to be summarized. The breeding experiments with wheat, corn, and other crops are being extended. Twenty experiments carried on in different parts of the State indicated that winter barley is likely to be a good crop for Indiana. Experiments with soy beans with reference to seed production gave relatively large yields. The use of soy beans to mix with corn is increasing in the State. The use of alfalfa is also rapidly growing. Some 800 farmers are cooperating with the station in experiments with different crops. Crop rotation and fertilizer experiments are being made in cooperation with the chemist in southwestern and southeastern Indiana. In Hamilton County the comparative efficiency of corn-cultural implements is being tested.

In the department of horticulture and forestry the experiments in spraying melons were continued in the region south of Vincennes. Increasing attention is being given to the diseases of watermelons and cantaloups. The onion industry in the northern part of the State is being investigated, as well as problems connected with the canning and shipping of tomatoes. Experiments were undertaken with pecan trees in southern Indiana, where these nuts grow wild but have not been cared for. The growing of catalpas and black locusts is being encouraged.

In animal husbandry the experiments with beef cattle included (1) influence of age, (2) value of silage, (3) use of concentrates, especially cotton-seed meal, and (4) long versus short feeding periods. New lines of work are experiments to determine the maintenance requirements of brood sows and the feeding of pigs from weaning time up to 250 pounds on rations varying from part middlings up to nearly all corn.

In the dairy department much attention was given to studies of condensed milk. A report on this subject was issued, but it is felt that further experiments are required.

In chemistry, in addition to the cooperative experiments with the agronomists, much analytical work was done on soils and in connection with plant breeding and dairy investigations.

The State chemist's office, located at the station, is doing a large amount of work in fertilizer and feeding stuff control. The law relating to feeding stuffs went into effect in 1907 and has proved very successful.

The present policy is to organize the station business as far as possible separately from that of the college of agriculture. The director and a number of station officers and special assistants are wholly employed in station work. The use of the new station building will complete and emphasize this separation.

Extension work was organized and actively prosecuted as station business under an act of the legislature passed in 1905. Beginning with September, 1908, this work will be organized as a division coming between the college and the station. The farmers' institute work was carried on as hitherto under Professor Latta in the college of agriculture. About 340 institutes were held in 1907–8. A change in policy throws the entire local expenses on localities and individual subscribers.

The college of agriculture is prospering and getting a much larger number of students than formerly.

The publications received from this station during the fiscal year were as follows: Bulletins 122, Alfalfa in Indiana. I. Results of experiments in late summer seeding. II. Suggestions for beginners in alfalfa culture; 123, Commercial melon growing; 124, Results of cooperative tests of varieties of corn, wheat, oats, soy beans, and cow peas, 1907; and 125, Commercial fertilizers; Circulars 8, Beef production. I. Purchasing feeders; 9, Commercial fruit growing; and 10, The use of fertilizers on southern Indiana soils; and the Annual Report for 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Miscellaneous	26,945.20
Balance from previous year	4,014.75
Total	54,959.95

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Indiana Station is more prosperous than ever before and is doing a large amount of useful work. With its new equipment, and the increasing interest of the farmers of the State in its operation, its outlook for the future is very promising.

IOWA.

Iowa Agricultural Experiment Station, *Ames*.

Department of Iowa State College of Agriculture and Mechanic Arts.

C. F. Curtiss, M. S. A., *Director*.

The Iowa Station continued to develop its work and equipment along the lines mentioned in the report for 1907. The new tracts of land were brought under experimental use and equipped to a considerable extent for such purposes. A large and substantial building for the use of the agricultural departments of the college, including the station, is making steady progress toward completion.

In addition to the two lines of work under the Adams Act reported in 1907, investigations were undertaken on apple breeding and a study of Mendelian unit characters in cattle breeding. Work on the study of humus formation is progressing steadily. For the project relating to the improvement of native cows, a number of Arkansas cattle were purchased, and are being compared with animals of the standard dairy breeds with reference to the effect of environment, feed, and breeding on the native animals and their offspring. The effort is to secure data which may form the basis for rational practice in the breeding of animals for use on dairy farms. A number of Galloway cattle were crossed with Grey blues, because it is thought that in this way Mendelian unit characters can be most effectively traced and studied. In the apple-breeding project the special object is to determine what characters are Mendelian. Nearly 10,000 seedlings have been planted, and some of these are already fruiting. A new orchard was planted on land well adapted to fruit growing. Chemical studies of apples are being made.

In addition to the Adams fund investigations, there is a large amount of experimental work in progress in various lines. For example, the department of chemistry is making an important study to determine the cause of calculi in sheep, which is supposed to be due to the feeding of roots. Mangels or beets were fed to rams, often in large quantities, and analyses of urine and feces were made. Other lines of work in this department are studies of the causes of corrosion of fence wire, experiments in the preparation of a new sheep dip, the extraction of sugar from pumpkins, and digestion experiments with pigs in which the animals were fed corn and three different kinds of stock foods as compared with the ordinary corn ration.

Soil investigations are being conducted at the station and in other parts of the State on the same scale as heretofore. One feature of this work consists of experiments on gumbo soils in eastern Iowa, which are treated to improve their physical condition. Field work

is supplemented by laboratory experiments along both chemical and physical lines. Peat experiments were made in five fields. The problems of such lands in Iowa are said to be different from those in Illinois. Pot cultures are being made to check field experiments, in which a variety of fertilizers and green manures are being used. As results accumulate, it appears that humus is the great need of the soils of the State. A description of a soil sampler devised by Professor Stevenson is given in Bulletin 94.

In horticulture the chief work of the station continues to relate to the adaptation of varieties, especially of orchard fruits, to the different regions of the State. Considerable work is being done on the breeding of apples for northern Iowa. Cooperative experiments on the cold storage of apples and on the care of orchards, including spraying, were continued. Experiments with reference to hardy stocks for commercial varieties of apples were begun.

Forestry experiments are being made in cooperation with the Forest Service. These include the treatment of posts and shingles for preservation and the breeding of catalpa and locust trees. In Iowa there is a large amount of land in bottoms and on hillsides along streams which originally bore considerable timber and should be replanted. Some experiments on such land were undertaken with red oak and other slow-growing trees, as well as with pines.

The department of entomology has recently been enlarged. Much attention was given to studies of leaf hoppers of apples, which are especially destructive in nurseries. Points in the life history of leaf hoppers in the northern part of the State were worked out. The oyster-shell scale did more damage than formerly, even in well-kept orchards, and an effort is therefore being made to discover more effective methods of spraying for this insect. Studies of the physiological effects of poisons on insects are being continued. Nursery inspection is going on as heretofore as a State enterprise.

In agricultural engineering, experiments were made in silo construction, an account of which has been published in Bulletin 100. A round silo made of building tile was designed and constructed at the station, which it is believed can be made more economical than the stone silo. Some work is being done on the construction and sanitation of dairy barns. There is also cooperation with the botanist regarding the mechanical means of grading grass seed. The sewage irrigation experiments in cooperation with this Office are being continued.

A poultry building and a number of small brooder and feeding houses were constructed on 20 acres adjoining the dairy farm. An expert poultryman was employed and experiments with hens were begun.

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In the departments of animal husbandry and field crops a large amount of work is in progress along much the same lines as heretofore.

Owing to the withdrawal of the officers in charge, the departments of dairying and veterinary medicine are undergoing reorganization.

The extension department of the college is demonstrating its usefulness as a means of carrying practical information to the farmers, enabling the station workers to devote themselves more closely to experimental work and bringing both college and station into closer touch with the schools throughout the State.

The publications received from this station during the fiscal year were as follows: Bulletins 91, Experiments in swine feeding. The value of corn and supplementary feeds for pork production (with popular edition); 92, Tuberculosis in swine (with popular edition); 93, Comparative values of alcohol and gasoline for light and power; 94, A new soil sampler (with popular edition); 95, The maintenance of fertility with special reference to the Missouri loess; and 96, Oats, varieties, seed, smut, seed-bed, seeding; Circular 1, Alfalfa (*Medicago sativa*). Popular editions were also received of Bulletins 74, 79, 83, and 88, the regular editions of which have been previously noted.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	22,750.00
Fees	15.00
Farm products	11,063.82
Miscellaneous	945.72
Balance from previous year	10,666.36
Total	69,440.90

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Iowa Station is in a prosperous condition and is doing a large amount of useful work for the benefit of the agriculture of the State.

KANSAS.

Kansas Agricultural Experiment Station, *Manhattan.*

Department of Kansas State Agricultural College.

E. H. Webster, M. S., *Director.*

There were few changes in the personnel of the Kansas Station during the past year. The dairy husbandman, O. Erf, resigned, and was succeeded by J. C. Kendall, formerly State dairy commissioner. The director tendered his resignation in April to take effect Septem-

ber 1, 1908. There were several additions and changes in the force of assistants. A department of bacteriology was established in charge of W. E. King.

No new projects were started under the Adams fund during the year, but substantial progress was made on the projects already begun, including the study of hog cholera, wheat breeding, milling qualities of Kansas wheats and the baking qualities of the flours yielded by them, digestion and nutrition experiments with prairie hay and alfalfa hay, and "cerebritis" in horses.

The department of agronomy carried on rotation experiments with wheat and variety tests of a number of farm crops, and in pursuance of its previous policy sold in small lots a large amount of improved seed of the cereals, broom corn, sorghum, flax, cowpeas, and soy beans.

The animal husbandman made feeding experiments with horses, cattle, sheep, and swine along the lines previously followed. The work with cattle consisted in comparing the gains on 2-year-olds, yearlings, and calves, when kept and fed for show purposes. An experiment with sheep was to ascertain the effect of shearing on fattening sheep. The experiments with hogs were to determine the effect of condimental feeds, meat meal, and alfalfa meal.

The bacteriologist conducted a preliminary investigation on the bacterial content of soil, using two types of soil and observing the influence of deep and shallow plowing. This work is being continued and the various activities of the bacteria found under different conditions are being determined. Individual species making up the flora are being identified. The work includes a comparative study of gravimetric and volumetric methods of bacteriological soil analysis.

In the botanical department the work has been practically all under the Adams fund and by far the greater portion has been on wheat breeding. In alfalfa breeding continued observations were made upon a large number of individual plants in respect to habit of growth, leafiness, form, size, and color of leaves, and color of the flowers. Selections of superior plants were made and extensive field studies were carried on. A rapid method of hand pollination of alfalfa flowers was discovered, and a method was worked out for the determination of the relative transpiration of water from the alfalfa plants of different types. The selection and multiplication of pedigreed alfalfa will be continued on a larger scale. About twelve distinct types are now in hand.

The chemical department had a large amount of work in connection with the feeding stuffs and fertilizer laws. In cooperation with the department of agronomy samples of alfalfa were secured at different stages of maturity under a plan to make complete analyses of them, including complete analyses of the ash in order to obtain much needed statistics concerning this crop and its relation to soil fertility.

A study of soil fertility in connection with the department of dairy husbandry was also undertaken. The latter department is operating a small dairy farm on a plan which it is expected will be continued for some years. The soils of several fields and pastures involved were carefully sampled, and it is proposed to observe the changes in composition that ensue under the management carried out upon this farm.

The resignation of Professor Erf made a break in the work of the dairy department. Some experiments were conducted to determine the efficiency and adaptability of moisture testers for ascertaining the moisture content of butter and a simple, inexpensive tester was designed by the department for making this determination. An exhaustive study is being made of the methods of making the Babcock test for cream. This work is of great commercial importance, because of the present method of buying and handling cream in the State. The work with poultry is in charge of this department and feeding experiments were continued. The second year of the egg-laying contest was also completed.

The work of the department of entomology and zoology dealt with a large number of insect pests and also the pocket gopher and prairie dog. Much of this has been in the field, the Hessian fly attracting most attention. The so-called "green bug," which received so much attention in the spring of 1907, attracted little notice after May and June, but in the following fall a few fields of wheat were found affected by it. Extended and detailed observations were made touching the Hessian fly and "green bug." Investigations on the prairie ant and pocket gopher were concluded and the results published. A study of the corn earworm was undertaken.

The horticultural department continued its tests of the applicability of the lime-sulphur wash as a preventive of scale and obtained results that indicate that it possesses a high fungicidal as well as insecticidal value. Peach trees to which it was applied in March were rendered practically free from the peach louse, while untreated trees were badly affected. The greatest value was evident in the prevention of brown rot, which caused serious loss on unsprayed trees, while the loss on sprayed trees was trifling. Late varieties suffered a heavier loss from rot than earlier ones, suggesting the need of a later spray. Some experiments were made in protecting peach trees and vineyards from late frosts by burning crude petroleum. The tests indicated that when the velocity of the wind is below 7 or 8 miles an hour the burning of crude petroleum at about 100 points per acre will afford protection down to a temperature of 22° F. Oil was burned at a rate of about 1 quart per hour at each point. Observations and tests of various varieties of fruit were continued,

and fertilizer tests on potatoes and vegetables indicated that special fertilizers are valuable with onions, celery, and lettuce, but have not been profitable with peas, beans, tomatoes, potatoes, and sweet corn. Nursery work with forest trees was continued, fair stands of most species being obtained. The two-year stratifying of red cedar seed again produced an excellent stand of young trees.

The work of the veterinary department was mostly confined to the Adams fund project. The treatment of contagious abortion in cattle also received some attention.

An appropriation of $1,000 was made by the legislature for experiments in the extermination of bindweed, which has become a serious pest in central Kansas, especially where land is seeded to wheat almost continuously. Work under the provisions of the act has been by two general methods: (1) Under the direction of the agronomist a number of different procedures, depending upon soil plowing and cultivation, have been tested; and (2) under the direction of the botanist the effect of spraying with solutions of chemicals is being tested. The experiments are still in progress.

The station staff assisted, as heretofore, in farmers' institute work, though to a somewhat less degree than previously. The farmers' institute work has been greatly enlarged, but is carried on chiefly by men employed especially for that purpose.

Nine bulletins and the Annual Report for 1907 were received from this station during the year. The bulletins were: 144, Small-grain crops; 145, Spraying; 146, Kansas law regulating the sale of concentrated feeding stuffs; 147, Indian corn; 148, Kansas law regulating the sale of commercial fertilizers; 149, Prevention of sorghum and Kafir corn smut; 150, The hen's place on the farm; 151, Alfalfa breeding—materials and methods; and 152, The pocket gopher.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United states appropriation, Adams Act	9,000.00
Fees	10,318.35
Farm products	7,020.31
Miscellaneous	2,960.21
Balance from previous year	5,878.31
State appropriation for substation	32,000.00
Total	82,177.18

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

Since the close of the year E. H. Webster, chief of the Dairy Division of this Department, has accepted the position of dean of agriculture in the college and director of the station.

KENTUCKY.

Kentucky Agricultural Experiment Station, *Lexington.*

Department of the State University.

M. A. SCOVELL, M. S., Ph. D., *Director.*

The work of the Kentucky Station during the past year has included a wide range of activities, in general following the lines of former years.

The greenhouses, with workrooms attached, recently completed at a cost of $9,000, will be used by the departments of chemistry and botany and will afford opportunities for a considerable amount of important experimental work. (Pl. I, fig. 2.)

A soil survey of the State has been undertaken in cooperation with the State geological survey.

Work on the Adams fund projects outlined in the report for 1907 has been steadily prosecuted during the past year. It is believed that a definite relation has been established between the organism causing nodules on the roots of sweet clover and that producing nodules on alfalfa and also between the organisms causing nodules on red clover and those on white clover. The life history of the corn earworm in the locality of the station has been practically completed. A method of analysis for determining the total phosphorus in soils has been worked out which is more rapid than the sodium-peroxid method and gives equally good results. Pot experiments in the greenhouses are now being employed in the soil investigations.

The chief work of the department of animal husbandry has been with pigs. An elaborate scheme of dry-lot experiments is being followed to compare corn ration with corn combined with middlings, soy beans, tankage, or fermented cotton-seed meal. It has been shown that corn alone is a poor feed to promote growth when fed to a young pig, a practice too commonly followed in Kentucky, but that as far as fattening the hog is concerned, corn can make up the bulk of the ration to advantage after the animal has reached a weight of 175 pounds. A new piggery with cement floor and iron barriers, with a special arrangement to keep the sow from trampling litters, is nearing completion. In the immediate vicinity of this building a number of dry lots are laid out and also acre lots platted for forage experiments. Some demonstration work in dipping sheep for scab has been conducted. Lately the station has been called upon to examine material from a number of cases of anthrax.

In dairy husbandry experiments in calf feeding have been made, and a record of feed and products of animals from an early age up has been continued as for several years past.

FIG. 1.—TOBACCO-BREEDING EXPERIMENTS, KENTUCKY STATION.

Field of White Burley tobacco grown from seed matured under paper bag and graded on the tobacco seed grading machines.

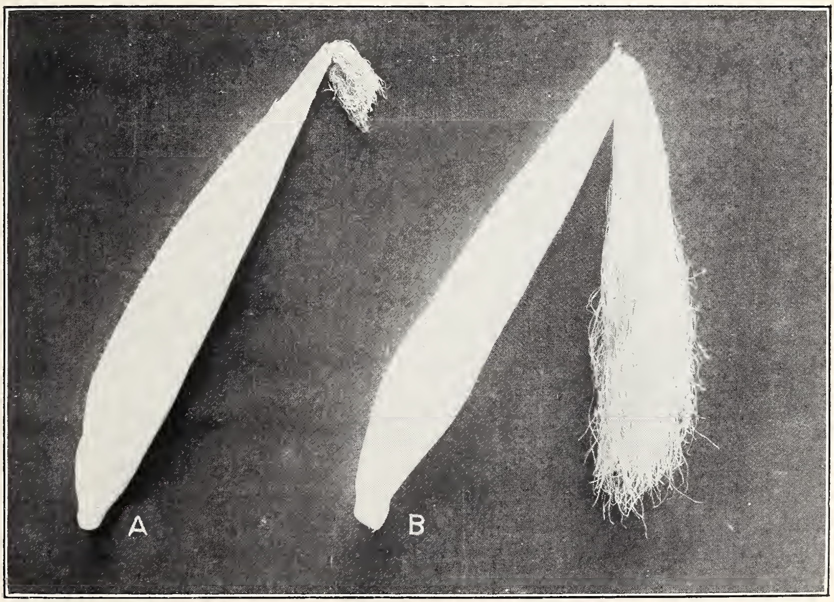

FIG. 2.—CORN-BREEDING EXPERIMENTS, KENTUCKY STATION.

A. Ear pollinated in the usual manner which produced only short silks. B. In this ear the silks were grown for ten days under paper bag to prevent pollination. The silks continued to grow and wait for the pollen.

Experimental work in agronomy is continued along the same lines as heretofore. Only a restricted area of the farm is used for plat experiments. Large areas are still used for crops and rotation to bring the land into condition for experimental use. It has been found, in work with the organism causing the rotting of tobacco, that it is identical with one causing the rotting of cabbage. It is believed that the grading of tobacco seed for the stations and for farmers sending it in to the station is having its effect on the tobacco of the State. The growing of tobacco seed under paper bags to prevent crossing is also giving beneficial results. (Pl. II, fig. 1.)

It has been established that the grains in the middle of the wheat heads have a higher percentage of protein than those from any other portion of the head; also, that weevils feed on the starchy portion of the grain more than they do on the nitrogenous portion.

The entomologist has recently taken up the study of the life history of the army worm, which did considerable mischief in the State last spring, and the study of the life history of a minute hothouse insect, which has proved very destructive to tobacco, tomatoes, clovers, and the like when grown under glass.

Numerous cooperative experiments are carried on in various parts of the State with farmers and with the Bureau of Plant Industry of this Department.

The last legislature changed the name of the college to State University and correlated it with the public-school system. An appropriation of $200,000 was made for new buildings and a permanent appropriation of $20,000 for maintenance. Thirty thousand dollars per year was appropriated for carrying out the provisions of a pure-food law under the direction of the station.

Three bulletins were received from the Kentucky Station during the year, as follows: Bulletins 130, The food of the crow blackbird, the corn rootworms; 131, Concentrated commercial feeding stuffs; and 134, Milk supply of Kentucky—Louisville.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams act	9,000.00
Fees, including balance from previous year	50,240.64
Farm products, including balance from previous year	10,810.51
Miscellaneous, including balance from previous year	365.16
Total	85,416.31

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Kentucky Station is in a highly prosperous condition; it is well equipped and liberally supported and is doing its work systematically and well. The entire separation of the control laboratories

from those used for research has been worked out very satisfactorily, and is contributing materially toward the greater efficiency of both lines of work.

LOUISIANA.

No. 1. Sugar Experiment Station, *Audubon Park, New Orelans.*
No. 2. State Experiment Station, *Baton Rouge.*
No. 3. North Louisiana Experiment Station, *Calhoun.*

Department of Louisiana State University and Agricultural and Mechanical College.

W. R. DODSON, A. B., B. S., *Director, Baton Rouge.*

The past year has been one of great activity at the stations, many important new lines of work having been inaugurated with the additional funds made available by the Adams Act.

Heretofore these stations have been unusually fortunate in retaining the continuous service of members of their staffs. They have, however, recently lost several of their most efficient men, more particularly the assistant director of the Sugar Station, R. E. Blouin, who has gone to Argentina as director of a sugar experiment station, and the chemist of the Sugar Station, Fritz Zerban, who has gone to Lima, Peru, to have charge of the government sugar station there. H. P. Agee has been appointed assistant director and P. A. Yoder chemist of the Sugar Station. The plant pathologist resigned at the beginning of the school year to accept a similar position at Pennsylvania State College, and was succeeded February 1 by C. W. Edgerton, of Cornell University. Soon after the close of the year W. L. Owen, formerly of the Georgia Station, was appointed bacteriologist of the Sugar Station.

Noteworthy progress was made in several of the Adams fund projects during the year. This is especially true of the investigations on the nonsugars of sugar cane, on root disease of cotton, pepper wilt, and diseases of the rice plant, on which reports were issued.[a] Progress reports on investigations on cerebro-spinal meningitis of horses and on anthrax were also published.[b] Several of the projects were more or less interrupted by changes in staff. Investigations on pou-a-poche of sugar cane and rice insects were undertaken as new projects during the year. The investigations reported on anthrax dealt with means of dissemination, preventive vaccination, and hyperimmunization. A practical result of the investigations was the demonstration of the need of efficient control of the preparation and distribution of vaccines. The rice diseases on which investigations were reported included blast, brown spot of grains, green smut, and

[a] Louisiana Stas. Buls. 100, 101, and 105.
[b] Louisiana Stas. Buls. 106 and 109.

black smut. The investigations on cerebro-spinal meningitis of horses, while not determining the cause or infective nature of the disease, made contributions to the knowledge of its pathology.

At the Sugar Experiment Station attention was given as heretofore mainly to experiments with seedling sugar cane; fertilizer experiments with sugar cane; methods of clarification of cane juices, more particularly the use of sulphur compounds for this purpose; tests of varieties and methods of culture of cotton and corn; and tests of various forage crops, fiber crops, citrus fruits, etc.

The work at Baton Rouge included finishing of cattle for market; relation of cattle feeding on the land to soil fertility; feeding black-strap molasses to calves; grazing hogs and sheep on fall-sown oats; cost of pork production on oats, rape, and sweet potatoes; improvement of cattle, sheep and hogs; tests of forage and root crops, including among others alfalfa, Egyptian clover, Guinea grass, sorghum, Japanese cane, and stock beet; tests of varieties of oats; and fertilizer experiments with corn, cotton, oats, and lespedeza.

Studies of methods of treating intestinal parasites of sheep were continued, as well as some investigations on anthrax, hog cholera, and tick eradication. Some attention was also given to investigation of various plant diseases and insects appearing during the year.

As heretofore, the horticulturist carried on tests of varieties of oranges, figs, pears, apples, grapes, persimmons, and various other fruits and vegetables on a small scale. He also continued tests of varieties and methods of propagating pecans and making crosses of grapes, and carried on fertilizer tests with vegetables.

The results of dairy investigations at Hammond, in cooperation with the Dairy Division of the Bureau of Animal Industry of this Department, have been reported.

The work at North Louisiana Station did not vary materially from that of previous years, and was largely in the nature of demonstration work, including fertilizer experiments with cotton, corn, and cane; tests of the Williamson method of corn culture; feeding experiments with steers; preservation of timber in cooperation with the Forest Service of this Department; and miscellaneous experiments with horticultural and truck crops.

The following publications of the station were received by the Office during the year: Bulletins 93, Second report upon the horse-flies of Louisiana; 94, The effects on the human system of Louisiana manufactured sirups and molasses; 95, Bare lot versus grass lot in relation to stomachal and intestinal parasitism of lambs; 96, Cotton wilt; 97, Analyses of commercial fertilizers and Paris green; 98, Analyses of commercial feeding stuffs; 99, Japanese persimmons; 100, The root disease of sugar cane; 101, Diseases of pepper and beans; 102, Report of dairy herds and their milk production at Ham-

mond, La., and vicinity; 103, Investigations on the use of sulphur and its combinations in the sugarhouse; 104, Feeding "blackstrap" molasses to young calves; and 105, Diseases affecting rice in Louisiana; Geological Survey Bulletins 4, Geology and underground water resources of northern Louisiana, with notes on adjoining districts; and 5, Notes on the geology of the Winnfield Sheet; Circular, Anthrax or charbon; and the Annual Report for 1907.

The income of the stations during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	10,000.00
Balance from previous year	4,911.97
Fertilizer fund	12,500.00
Farm products	3,619.25
Insurance	250.00
Total	55,281.22

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The work of the Louisiana stations has been energetically prosecuted during the past year along well-established lines, and more advanced scientific investigation has been developed along several important lines. It seems to be the wise policy of these stations to concentrate their efforts mainly upon investigations centering on a few subjects, e. g., sugar, cotton, rice—most important to the agriculture of the State.

MAINE.

Maine Agricultural Experiment Station, *Orono*.

Department of the University of Maine.

C. D. Woods, Sc. D., *Director*.

The work of the Maine Station during the past year was chiefly a continuation of lines of investigation which had been well established during previous years. It was marked, however, by considerable changes in organization and improvement in laboratory equipment looking toward the development of the study of the more scientific problems growing out of the previous work. There was also concentration of effort along the more important lines of investigation, the general purpose being to center these investigations around three or four subjects.

The Adams fund work of the station was grouped about breeding problems with hens and corn, and diseases of the potato (more particularly scab and allied fungi) and of the apple (particularly spot

diseases). The food investigations which have been carried on by the station for a number of years were discontinued. The investigations in breeding and on potato diseases are beginning to yield results of much scientific value and practical importance.[a] The investigations on apple diseases have been more recently inaugurated, but are already well advanced. Several technical papers on various phases of the Adams fund investigations have been published.

Hatch funds are used to supplement the Adams fund in the above investigations.

A department of biology was established at the beginning of the year to study the more advanced problems of heredity and breeding in corn and fowls, and the work was placed in charge of the associate biologists, Drs. Raymond Pearl, of the University of Michigan, and F. M. Surface, of the University of Pennsylvania. As an outcome of the first year's work in this department, there has been a systematizing and improvement of methods of keeping records (improved pedigree records and trap nests), a careful analysis of previous records, a clear statement of the practical and scientific progress already made, and a definite outlining of the scientific problems demanding further study. The first part of the analytical study of the records has been submitted for publication by this Department through the Bureau of Animal Industry,[b] with which the station is cooperating in these investigations.

Some of the practical results of the nine years' work with poultry were summed up during the year and submitted for publication as a Farmers' Bulletin of this Department.[c] The more important of these results are the demonstration of the practicability of the curtain-front poultry house, dry-mash feeding, crate fattening, and methods of rearing chicks.

F. L. Russell, veterinarian, was associated with Doctors Pearl and Surface in the poultry-breeding work in a study of the biology of egg production. Doctor Russell's work is in the form of "physiological experiments on rate of formation of the yolk, and on the time relation of the processes of ovulation and of the formation of the egg in the oviduct."

Prof. G. M. Gowell, in charge of the poultry experiments from their beginning in 1898, resigned from the station staff December 31, 1907. He died May 6, 1908.

The work on plant diseases was strengthened during the year by the appointment of C. E. Lewis, Ph. D., of the University of Wisconsin, as associate vegetable pathologist. In addition to the in-

[a] Maine Sta. Buls. 149, 157, and 159.

[b] U. S. Dept. Agr., Bur. Anim. Indus. Bul. 110, pt. 1.

[c] U. S. Dept. Agr., Farmers' Bul. 357.

vestigations already referred to, this department cooperated during the year with H. A. Harding, of the New York State Station, in the completion of a monograph on soft rot of vegetables, and carried on experiments in breeding disease-resistant potatoes.

L. H. Merrill, chemist, retired from the station staff to devote himself entirely to university work, with the close of the last fiscal year, and food investigations to which he had been giving particular attention were discontinued.[a]

The entomological work of the station, which has steadily grown in importance, deals very largely with potato and orchard insects, although the entomologist investigates local insect outbreaks and during the past year made special studies of the saddled prominent (*Heterocampa guttivita*), and gave considerable time to the preparation of a monograph on the life histories and classification of Aphididæ.

The horticulturist resigned from the station staff at the close of the last fiscal year to accept a position with the West Virginia University and Experiment Station. The work which he had carried on since 1891 has been largely discontinued for the present owing to the lack of suitable facilities and equipment for such work. The station, however, will continue studies of insect enemies and diseases of orchard fruits. The results of ten years' cooperative experiments with methods of culture, fertilizing, spraying, etc., in a private orchard in Kennebec County were summarized and published during the year.[b]

The outside cooperative work of the station at present consists mainly of experiments in breeding sweet corn at Farmington and on the culture of potatoes and with lime on clover in Aroostock County.

Additional library, office, and laboratory rooms were fitted up during the year. A greenhouse for use in plant-disease investigations has been built.

A department of photography has been organized to handle in a systematic and efficient way the large amount of photographic work incidental to the various lines of investigation of the station.

Much of the correspondence formerly done by station men is now referred to the agricultural department of the university or handled in the director's office, so that this is no longer a burdensome feature of the work of the individual members of the station staff. No institute work is required of station men, and only occasionally are they expected to make addresses at meetings of farmers' organizations.

The inspection work, including fertilizers, foods, drugs, feeding stuffs, seeds, dairy glassware, Paris green, prepared Bordeaux mixtures, etc., was as in previous years large and exacting, the examination of about 200 brands of fertilizers, 200 samples of seeds, 400 of

[a] For the final report on these investigations see Maine Sta. Bul. 158.
[b] Maine Sta. Bul. 155.

foods and drugs, and 500 of feeding stuffs being now required annually. An important fact brought out by the inspection is the occurrence of large amounts of live weed seeds in certain kinds of feeding stuffs and agricultural seeds. These are large enough to constitute a dangerous means of dissemination of noxious weeds.

A new agricultural building for the university, the corner stone of which was laid June 10, 1908, and which is to cost $50,000, is approaching completion. The attendance in the agricultural courses of the university has steadily increased, and these courses and the extension work of the university have been considerably developed.

The following publications have been received during the year: Bulletins 143, Preliminary notes on the seedling apples of Maine; 144, Poultry experiments; 145, Food inspection; 146, Fertilizer inspection; 147, The potato plant louse; 148, Insect notes for 1907; 149, Potato diseases in 1907; 150, Finances, meteorology, index (including annual report); 151, Food and drug inspection; 152, Seed inspection; 153, Fertilizer inspection; 154, Paris green, Bordeaux mixture; 155, Orchard notes, 1907; 156, Feeding stuff inspection; and 157, Poultry work at the Maine Station.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Inspector's fees, sales, etc	10,238.70
Balance from previous year	3,583.96
Total	37,822.66

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Maine Station has been strengthened during the year in organization and plan of work, and is vigorously prosecuting the fundamental inquiries which promise to be most productive of valuable scientific and practical results in its wisely chosen field of work.

MARYLAND.

Maryland Agricultural Experiment Station, *College Park.*

Department of Maryland Agricultural College.

H. J. Patterson, B. S., *Director.*

The past year at the Maryland Station has marked a decided broadening of the scope of the investigations and an increase in the equipment and facilities for this work.

In addition to the two Adams fund projects, mentioned in the report for 1907, work has been undertaken in the following lines: Effects of fertilizers on cell structure of plants and their relations

to mutations; influence of systems of housing and feeding on the embryology of chickens; and a study of parasitic hymenoptera, with special reference to the family Braconidæ. Much of this work involves the cooperation of different departments of the station. The veterinarian's laboratory has been especially equipped for Adams-fund work. A large amount of chemical, microscopical, bacteriological, and entomological work has been done on the various projects. Work on the greenhouse pests under this fund has been discontinued and a summary of results reached in this line has been made in Bulletin 119 of the station.

Among the enterprises pursued with the Hatch and State funds are the following: In agronomy a considerable amount of breeding work with corn, wheat, cowpeas, alfalfa, and clovers is in progress.

The botanical department is cooperating with the Bureau of Plant Industry of this Department in a plant-disease survey.

The work in chemistry included a continuation of the sweet-corn investigations and pathological and physiological studies on milk.

Considerable work has been done in the study of conditions attending the making of butter in Maryland. Many dairies and creameries in the State have been visited and notes made on the conditions existing there and quality of product. Butter on the market has also been scored. For this work the score cards of the Bureau of Animal Industry of this Department have been used. The aim of this work is to secure a definite basis for the improvement of Maryland butter. A study has also been made of the conditions attending the whipping of cream, and interesting data have been obtained.

Studies have also been made of tainted conditions of milk as related to the physiological condition of the animal, and important data have been obtained showing that tainted milk is not altogether due to the introduction of foreign substances, but to pathological conditions of the animal.

The principal work in entomology has included tests and experiments with insecticides; work on the peach lecanium has also been finished.

In horticulture, chief emphasis is being put on the orchard work and on fertilizer experiments with vegetables. An attempt to stimulate nut growing in the State, especially Persian walnuts and pecans, has been made. Special attention is being given to pear breeding in an attempt to combine the hardiness, vigor, and productiveness of the Kieffer with the good qualities of the Seckel, Anjou, and Duchess.

The poultry department conducted experiments comparing the effect of wet and dry mash on egg production with two-year-old hens. An attempt is also being made to breed barred Plymouth Rocks for egg production.

The veterinarian has done much work in connection with milk studies and has made a number of tuberculin tests and vaccinations. He has also made investigations of cerebro-spinal meningitis.

In animal husbandry, digestion experiments were made with a steer to determine the value of oat hulls. These were also fed to pigs and horses without digestion experiments. Oat hulls are really a mixture of hulls and light oats, and the results of this investigation show that this mixture has nutritive value.

The last legislature passed an act making the board of trustees of the college ex officio the State board of agriculture and the director of the station the secretary of that board.

Nine bulletins and the Annual Report for 1907 were received from this station during the fiscal year. The bulletins were as follows: Bulletins 117, Digestibility of molasses feeds; 118, Alfalfa in Maryland; 119, Greenhouse pests of Maryland; 120, Sweet-corn investigations; 121, The beef-cattle industry in Maryland; 122, Stable-manure experiments; 123, San José scale and the peach lecanium; 124, Strawberries; and 125, Nut growing in Maryland.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	20,500.00
Balance from previous year	501.74
Farm products, including balance from previous year	5,767.79
Total	50,769.53

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The work of the Maryland Station is proceeding in a steady and orderly manner. The experimental work has increased considerably in extent in recent years, and is securing more substantial support in the State.

MASSACHUSETTS.

Massachusetts Agricultural Experiment Station, *Amherst.*

Department of the Massachusetts Agricultural College.

W. P. Brooks, Ph. D., *Director.*

Few changes in personnel occurred at the Massachusetts Station, except in the case of assistants. Considerable equipment was added and the work of reorganization was continued to give additional facilities for research work. An appropriation of $4,000 was received for changes and improvements in the administration building. A large fireproof vault was constructed and numerous other changes

and repairs made. The equipment of Clark Hall was completed, and a hothouse, 78 by 28 feet, with a propagating house, 39 by 5 feet, was constructed for use in experiments connected with plant pathology and physiology.

The work of the Adams fund projects outlined in last year's report was continued and considerable progress made. As a result of substation work, methods of preventing injury from cranberry insects were discovered and are being prepared for publication. In the asparagus breeding, selected plants from all parts of the world were studied and some hybrids were produced. The study of the relation of climate to plant diseases was continued. A large amount of data was collected, based on observations both out of doors and in the greenhouse. Careful records of the light intensity are being kept and use is made of the records of the meteorological department. In this work records of the different diseases and dates of their appearance are kept. Much apparatus was tested and constructed for the special work of this investigation. In the study of insecticides the purity of the materials with which the work is to be done is being determined. The study of the plant-food requirements of various crops is being carried on by means of analyses of plant roots to determine the effect of different fertilizers on organic composition and by means of determinations of the composition and peculiarities of the soil at different depths. The investigation of the effect of molasses on the digestibility of hay seemed to show that when 20 to 25 per cent of the dry matter of a ration is derived from molasses the digestibility of the other constituents is depressed, but that this effect is not noticeable when only 10 to 15 per cent is so derived.

Besides Adams fund work, the agricultural department conducted the usual number of plat experiments with fertilizers and manures in the open field, inclosed plat experiments, and pot experiments. The experiments especially supported the conclusions that the feeding capacity of crops does not appear to bear any very direct relation to their composition, and that this, rather than composition, should control in the selection of fertilizers. The work with poultry was continued, and concerned itself with problems connected with feeding for egg production. This still further confirmed the fact that satisfactory egg production is possible when the principal grain fed is corn.

The chemical department studied the effect of a continuous hay and a hay and grain diet upon the composition of butter fat during an entire lactation period; the amount of digestible protein necessary for profitable milk production; the acidity, coloration, and sulphite content of gluten feed, and the composition of soils on which tobacco has long been grown. It was found that normal rations have little effect on the composition of butter fat; that the amount of protein for maintenance plus that actually contained in milk is not

sufficient to keep up a satisfactory flow of milk; that gluten feeds commonly show acidity. The latter appears to be due in part to sulphuric and phosphoric acid salts, and in part to organic acids resulting from fermentation. Such feeds also are frequently colored with anilin dye, but the quantity present has not been found sufficient to be injurious.

The horticulturist carried on experiments in grafting, pruning, and hybridization, and studies of variation, physiological constants, and the use of enzyms in germination. The most important practical result attained was the development of the best methods of managing dwarf fruit trees under American conditions.

The department of vegetable pathology and physiology made investigations of the mosaic disease of tobacco and tomato, of the influence of certain climatic factors on disease, of onion smut, bacterial disease of onions, a new bacterial disease of celery, and some special diseases of ornamental trees. The experiments relating to testing and separation of seeds were continued.

The entomologist made studies of treatments for the cabbage maggot, fumigation of melons under glass, control of onion thrips, dates of appearance of the young of the more common scale insects, and the importance of the second brood of the codling moth.

The veterinary department made a study of the ventilation system of the college stable and carried on experiments which indicate that it is especially dangerous to feed cattle with forage taken from beneath trees sprayed with arsenate of lead.

The department of meteorology made the usual observations and prepared to summarize the records for the past twenty years.

Work was carried on at substations at Falmouth and Wareham with cranberries, and at South Amherst with apples. The Bureau of Plant Industry of this Department cooperates in work on rust-resistant asparagus.

The following publications were received from this station during the fiscal year: Bulletins 118, Molasses and molasses feeds for farm stock; 119, Inspection of commercial fertilizers; 120, Inspection of commercial feed stuffs; 121, Seed separation and germination; 122, Poultry keeping for egg production; and 123, Fungicides, insecticides and spraying directions; Circulars 1, Cotton-seed meal; 2, Cutworms; 3, The apple maggot, or railroad worm; 4, Wireworms; 5, Root maggots; 6, The lecaniums, or soft scales; 7, Ants; 8, Bulletins of the agricultural experiment stations of Massachusetts, 1883–1907; 9, Rules relative to testing dairy cows; 10, The sampling and sending of fertilizers, soils, and feed stuffs for free examination; 11, Chemical analysis of soils; 12, The unprofitable cow and how to detect her; 13, Laws regulating the sale of commercial fertilizers in

Massachusetts; and 14, Fertilizers for potatoes; Meteorological bulletins 222–233; Index bulletins and reports, 1888–1907; and the Annual Report for 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	13,500.00
Balance from previous year	11,533.31
Fees	5,165.00
Farm products	2,732.07
Miscellaneous	5,762.26
Total	62,692.64

A report of the receipts and expenditures for the United States funds has been rendered in acordance with the schedules prescribed by this Department and has been approved.

MICHIGAN.

Experiment Station of Michigan State Agricultural College, *East Lansing.*

Department of Michigan State Agricultural College.

R. S. SHAW, B. S. A., *Director.*

The Michigan Station has undergone considerable reorganization during the past year. Director Smith resigned in the spring to accept the presidency of a school of agriculture in Brazil and was succeeded by R. S. Shaw. Dr. C. E. Marshall was made vice-director in general charge of all scientific work.

Work has been prosecuted under the Adams fund along the five lines stated in the report for 1907, and also on some of the fungi instrumental in destroying insects and on the manner in which insecticides kill. The life histories of fungi affecting insects are being studied, as well as the methods and results of infection. The investigations on the bacterial associations in the souring of milk were pursued for several years and the results have recently been published as Special Bulletin 42. Considerable work has been done on the factors influencing the keeping qualities of butter. This is regarded as preliminary to the more intense investigations now being pursued. Some results of the study of the agents rendering available the insoluble elements of the soil have been published in Special Bulletin 43, The solvent action of soil bacteria upon the insoluble phosphate of raw bone meal and natural rock phosphate. This investigation is being broadened so as to include physical and botanical as well as chemical and bacteriological phases of the subject. The studies of the "Grand Traverse disease" of cattle have indicated that a certain

treatment is efficacious, but further investigations as to the real cause of the disease are contemplated.

Work in the department of entomology outside of the Adams fund has consisted chiefly of studies of the life histories of insects not hitherto fully described, with special attention to forest insects.

In chemistry, fertilizer experiments have been made for the past two years in the southern part of the State near Edwardsburg, where the bacterial content of the soil was small. Last year 2 tons of clover per acre were obtained as compared with previous yields of 2 tons per 20 acres, and 31 bushels of wheat as compared with 9 bushels previously. Lime was found to help clover, but not other crops. This work will be continued for four or five years.

In connection with the corn-breeding work, nitrogen determinations with corn have been made showing no constancy in the nitrogen in the kernels on the same ear and differences of 5 per cent. It is planned to make studies of dried peat compared with other absorbents of manure in stables.

In dairy husbandry and manufacture, studies are being made relating to the production of sanitary milk under farm conditions. These include experiments accompanied with demonstrations. There have also been some feeding experiments with dairy cattle, and work in this department is carried on in cooperation with the bacteriologist.

In animal husbandry, sheep experiments have been conducted during two years as to the effect of a succulent ration on yield of lambs, milk, and wool. With pigs there have been no experiments recently because of hog cholera. The herd is now being restored and immunized, and experiments will be continued with reference to the production of a type of animal intermediate between the lard and the bacon pig. With horses the experiments with cheap versus expensive ration have shown the cheap ration to be equally good. Beef-cattle experiments have been made with reference to economic feeding of grade cattle, and for the past three years experiments have been made with pail-fed versus suckling calves.

The work in poultry husbandry thus far has been mainly the establishment of a plant. Buildings and yards have been erected, incubators bought, and fowls of different kinds purchased.

The horticulturist has been conducting extensive experiments with the use of commercial fertilizers as applied to certain fruit crops in the fruit district of the State. He has also carried on extensive and beneficial tests relative to the use of sprays in combating grape diseases, causing serious loss to grape growers. This work has been unusually successful. Other work in horticulture has included breeding experiments with potatoes and strawberries and an investigation of the diseases affecting lettuce when grown under glass.

The station has been cooperating with this Department in the production of sugar-beet seed, the testing of varieties of sugar beets, and the growing of alfalfa and other forage crops, in cultural methods relating to corn cultivation, and also in a triangular experiment where corn is grown at three different institutions in different parts of the United States for a number of years and then changed about from place to place.

A new agricultural building, which will be used by the station as well as the college, is in process of erection. This building, when completed, will cost $200,000. (Pl. III, fig. 1.)

The publications of this station received during the year were: Bulletins 246, The practical use of starters; 247, Dried beet pulp for fattening steers; 248, Fertilizer analyses; 249, Protection of buildings from lightning; and 250, College farm buildings; Special Bulletins 38, Thrips on oats; 39, Pollination of forced tomatoes; 40, Report of South Haven Substation for 1906; 41, Report of the Upper Peninsula Substation for the years 1905 and 1906; and the Annual Report for 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$14,676.10
Balance from previous year, Hatch Act	323.90
United States appropriation, Adams Act	8,650.00
Balance from previous year, Adams Act	350.00
State appropriation	30,500.00
Farm products from substations	2,313.94
Fees	3,215.00
Miscellaneous	2,185.80
Balance from previous year	473.91
Total	62,688.65

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

With the aid of State funds, a much larger amount of the more practical work is being done than formerly. On the whole the affairs of this station are in good condition and the new administration gives promise of increased usefulness.

MINNESOTA.

Agricultural Experiment Station of the University of Minnesota,
St. Anthony Park, St. Paul.

Department of the University of Minnesota.

E. W. Randall, *Director.*

The personnel of this station was enlarged and the facilities materially improved during the year. Some important changes in organization were made. A new department of botany and plant

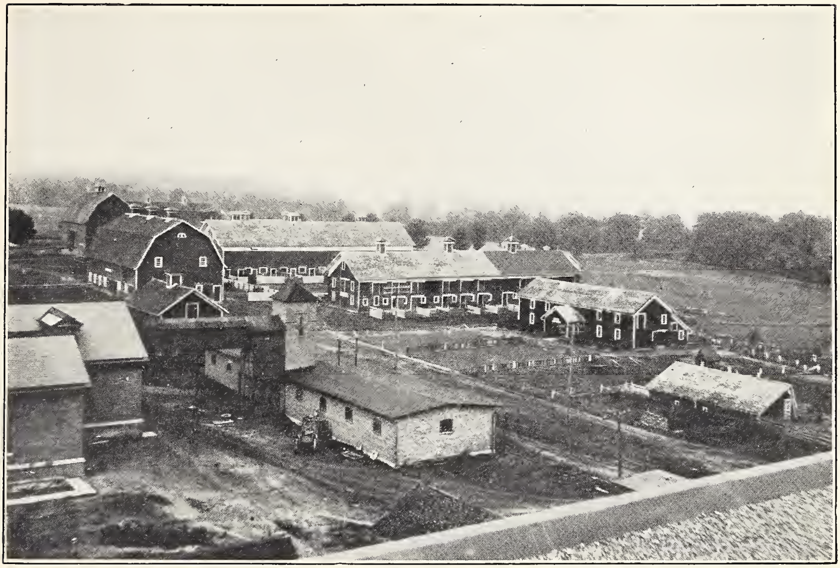

FIG. 1.—REARRANGED GROUP OF FARM BUILDINGS, MICHIGAN STATION.

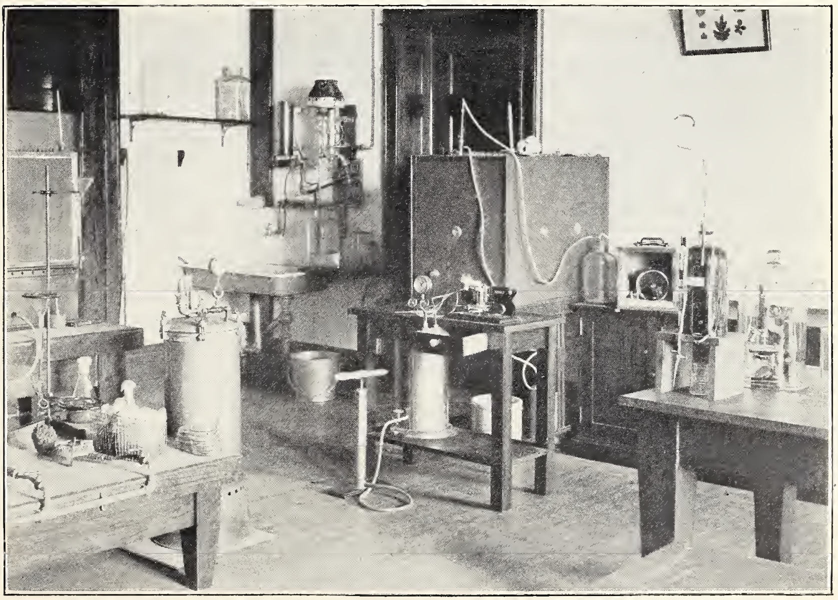

FIG. 2.—BOTANICAL RESEARCH LABORATORY, NEBRASKA STATION.

pathology, with E. M. Freeman, formerly of the Bureau of Plant Industry of this Department, in charge, was created, and the department of dairying was enlarged to include animal nutrition. The duties of the department of horticulture and forestry were greatly enlarged as a result of liberal State appropriations for forestry work in a reserve of 20,000 acres at Lake Itasca and for the establishment of a fruit farm at Excelsior ($16,000 and $2,000 annually for maintenance) better suited to experimental work than the station farm. The field work has benefited by the addition of 148 acres of land to the station farm, for purchase of which the last legislature made an appropriation of $76,000.

Marked progress was made in all of the Adams fund projects enumerated in last year's report. Several of them have been so developed as to require a supplementing of the Adams funds available for their maintenance. Reports of progress in case of several of the projects have been published. The investigations on the theory and practice of cereal breeding have been enlarged, modified, and made more definite by participation of the botanist and plant pathologist (Freeman) in the work, particularly in connection with the breeding for rust resistance in wheat and oats. The other features of this project have not materially changed. A new project, growing out of previous investigations, and involving the study of the principles of heredity underlying disease and climatic resistance in the apple, plum, and strawberry, was inaugurated during the year. The investigations on the food requirements of milk production, a progress report on which was published during the year,[a] was extended to include a study of the food requirements of beef production, and a new laboratory for the chemical work involved was fitted up and equipped. Investigations on stable ventilation were continued with improved facilities, and extended to include a study of the influence of light or lack of light in stables. A summary of the results of the first ten years' work on the influence of methods of farming upon the fertility of characteristic soil types of the State, which in recent years has been carried on as an Adams fund project, was published during the year.[b] The entomological projects were considerably modified during the year and were centered mainly around life-history studies of *Empoasca mali*, *Macrosiphum granaria*, and *Bruchophagus funebris*. Reports of progress on certain phases of this work were issued during the year.[c]

In addition to these Adams fund investigations, the agriculturist has in progress a large number of experiments in improvement by breeding and selection of farm crops, including wheat, rye, oats, barley,

[a] Minnesota Sta. Bul. 106.
[b] Minnesota Sta. Bul. 109.
[c] Minnesota Sta. Bul. 108.

corn, cowpeas, soy beans, Canada field peas, clover, alfalfa, hemp, Bromus, timothy, and root crops. The work of this department also includes tests of varieties of various farm crops, rotation experiments, and studies of farm management, the latter including the systematic collection, in cooperation with this Department, of statistics relating to cost of production on representative farms in different parts of the State. The system of rotation experiments has been enlarged and improved with the acquisition of additional farm land.

Tangible results from the plant-breeding nursery have been obtained during the past year. Several very promising varieties of grains developed from that source are now being increased for distribution. Minnesota No. 2 rye was given a somewhat extended trial at various points in the State during the year with very gratifying results. From funds appropriated by the legislature for plant-breeding work, 12 corn-breeding stations have been established where varieties are being tested and an effort made to breed varieties especially adapted to the local conditions of different sections of the State. An experiment to determine whether or not macaroni wheat would deteriorate and become soft and starchy on heavy, moist soils, undertaken as a part of the breeding work, was completed during the year.

In animal husbandry careful herd records were kept as heretofore, and experiments with forage crops for live stock, in breeding milch Shorthorns, in cooperation with the Bureau of Animal Industry of this Department, and the management of swine in summer were continued. Feeding experiments with work horses and colts and pasture experiments with sheep were undertaken, as well as breeding experiments with sheep and a study of factors affecting the quality of wool.

The veterinarian gave considerable attention to tests of the new serum treatment for hog cholera, to swamp fever in horses, and to the dissemination of tuberculosis.

In the department of dairying and animal nutrition, investigations on the relation of the natural flora of milk to the use of commercial cultures were undertaken and experiments on the food requirements of swine were planned.

In horticulture, experiments in breeding potatoes with special reference to resistance to Fusarium rot and with reference to seed production, and the crossing of Japanese and American plums, of wild Alaska and cultivated strawberries, and of grapes were continued. Tests of varieties of vegetables and of ornamentals, particularly peony and rose crosses, were also carried on.

The chemist continued investigations of the bread-making quality and food value of wheat and flour, particularly in relation to fertility of the soil, and undertook investigations on the manufacture of alco-

hol from such products as sugar beets, cull potatoes, and unsalable grain.

In the new department of botany and plant pathology a beginning was made in a general survey of the botany and plant pathology of the State, and in special studies of fruit diseases, cereal smuts (of barley, wheat, and corn), damping-off of coniferous seedlings, and timber diseases. The examination of seeds was also undertaken.

The work of the entomologist included nursery inspection, tests of liquid and dust sprays for fruit trees, experiments with hydrocyanic-acid gas for scale insects and with arsenate of lead for the plum curculio, and studies of life histories and distribution of a number of insects prevalent in the State, more particularly during the past year the so-called green bug or grain aphis. Investigations on the cabbage maggot (*Pegomyia brassicæ*) were continued.

At the Northwest Substation at Crookston a very complete drainage system was installed in cooperation with this Office and is now in successful operation. Experiments were carried on at the station in the feeding and management of farm animals and the production of forage crops, particularly clover and timothy.

At the Northeast Substation at Grand Rapids attention was given to the production of miscellaneous crops and animal products to supply the local markets for such products among miners, manufacturing concerns, and shipping interests.

The following publications of the station were received by the Office during the year: Bulletins 102, Soil investigations; 103, Dissemination of tuberculosis by the manure of infected cattle; 104, Pork production; 105, The importance of the study of entomology—how to collect and preserve insects; 106, Investigation in milk production—the relation of nutriment to product; 107, Corn breeding in Minnesota; and 108, The so-called "green bug" and other grain aphids in Minnesota in 1907; and the Annual Reports for 1906 and 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	8,643.08
Balance from previous year, Adams Act	356.92
State appropriation, including substations	62,440.83
Farm products, including substations	12,966.11
Total	99,406.94

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

As a result of liberal State support the work of the Minnesota Station was broadened and strengthened during the year by important additions to the equipment of buildings, land, etc., and to the scientific staff.

MISSISSIPPI.

Mississippi Agricultural Experiment Station, *Agricultural College.*[a]

Department of Mississippi Agricultural and Mechanical College.

W. L. HUTCHINSON, M. S., *Director.*

The lines of work of this station have not changed materially during the year. There has been some improvement in organization, especially with a view to reducing teaching and institute work by station men. The State has provided for the organization of an extension department of the college, and this will doubtless tend to still further relieve station men. A bacteriologist, R. P. Hibbard, of the Bureau of Plant Industry of this Department, was added to the station staff near the end of the year. Shortly after the close of the year J. C. Robert, veterinarian, and G. W. Herrick, entomologist, resigned. A. Smith was succeeded by J. A. McLean, of the Iowa Station, as animal husbandman of the station.

Work was continued during the year on all of the Adams fund projects enumerated in last year's report. No new projects were undertaken. Decided progress was made in the work on scale insects, and other projects were developed. The mule breeding project exceeds all others in cost, scope, and prospective importance. The preliminary stages of the investigations on the hygiene of the milking machine and on the physiological effect of cotton seed and cotton-seed meal on milch cows were passed during the year, and these projects were put in shape to be developed along more scientific lines.

In addition to the Adams fund investigations the following work was done: In agronomy the rotation experiments with representative southern crops (corn, oats, cotton, clover, and cowpeas) were continued, as well as cultural and variety tests of corn, cotton, alfalfa, cowpeas, and soy beans. Experiments in the improvement of corn and cotton by selection and with fertilizers for cotton were also carried on. Tests of miscellaneous forage crops (lespedeza, mangels, etc.) were made.

The time of the animal husbandman was largely devoted to the Adams fund project on mule breeding and the care of the herds of the college and station, but he carried on feeding experiments with beef cattle and hogs. In dairy husbandry considerable work was done on the improvement of the dairy herd and of the pastures, and experiments with various rations of typical southern feeds, soiling crops, etc., for dairy cows, were made.

The biologist made some study of corn insects, household insect pests, chicken pests, and miscible oils for San José scale.

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[a] Telegraph address, *Starkville;* express and post-office address, *Agricultural College;* freight address, *A. and M. College Station.*

In horticultural lines tests were made of varieties and methods of culture of grapes, peaches, strawberries, tomatoes, pecans, and ornamental plants. Nurseries of locust, pine, and hickory were planted in cooperation with the Forest Service of this Department. Experiments were also made with hybrid seedling strawberries, and in outdoor versus indoor culture of carnations. New plantings of orchard fruits were made and a horticultural barn was constructed.

The poultry work of the station, including both chickens and turkeys, proceeded along the same lines as heretofore. It consists largely of comparatively simple experimental features, such as trapnest records of hens for improvement of egg-laying capacity and observations on cost of broiler production.

The substations at McNeill, Delta, and Holly Springs are well supported by the State and were very successful in their work. The last legislature appropriated $13,200 for the support of the McNeill Substation for two years, $12,000 for the Holly Springs Substation, and $10,600 for the Delta Substation. The Delta Substation had in addition during the past year a sales fund of about $10,000. The work at McNeill included mainly fertilizer and culture experiments with cotton, corn, sugar cane, and various truck crops, rotation of crops, and feeding of beef cattle; at Delta, experiments with cotton, alfalfa, and other forage crops, and pork production; at Holly Springs, cultural methods and cropping especially suited to restoring badly eroded soils.

The last legislature appropriated $1,000 for station printing.

The publications of the station received during the year were as follows: Bulletins 99, Fertilizers; 101, Report of work at McNeill Branch Experiment Station for 1906; 102, How to control injurious insects and noxious plant diseases; 103, Corn improvement in Mississippi; 104, Inspection and analyses of cotton-seed meal on sale in Mississippi; 105, Inspection and analyses of commercial fertilizers on sale in the State; 106, Report of work at the Delta Station for 1906; 107, Pork production at the Delta Station; 108, Report of work at Holly Springs Branch Experiment Station, 1906; and 109, The adornment of rural school surroundings.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation for substations	[a] 30,075.00
Farm products, including substations	15,473.07
Miscellaneous, including substations	260.69
Total	69,808.76

[a] For two years.

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

During the past year this station made progress in the differentiation of station, college, and commercial work, which is essential to the highest efficiency of the station, and in extending the influence of its work throughout the State.

MISSOURI.

Missouri Agricultural College Experiment Station, *Columbia*.

Department of the College of Agriculture and Mechanic Arts of the University of Missouri.

H. J. WATERS, B. S. A., *Director*.

No new investigations of any special importance were undertaken during the year at this station, but old lines of work were extended and strengthened. A number of changes in personnel occurred. Dr. P. F. Trowbridge, formerly associate chemist, was made chemist. Numerous changes took place during the year in the force of assistants. Since the end of the fiscal year, C. Stuart Gager, Ph. D., director of the research laboratories of the New York Botanical Gardens, has been appointed botanist.

Experiments and investigations under way under the Adams fund remained unchanged, except as they are naturally increased and developed.

The principal investigations were the nutrition work with beef and dairy animals, hogs, and sheep, the soil survey, crop and fertilizer tests on the principal types of soil of the State, plant breeding, factors affecting the hardiness of plants, orchard fertilizer experiments, studies of plant and animal diseases, hog cholera, and tuberculosis.

The station veterinarian met with remarkable success in the inoculation of hogs against cholera, the work being done in conjunction with the Bureau of Animal Industry of this Department. The demand from farmers for antitoxin far exceeded the supply, and efforts are under way to produce it in sufficient quantity.

It was found that the way in which a peach tree, for example, is pruned and handled in the summer will affect in a very striking way its ability to withstand the cold the following winter, and the way seems to be clear now to increase materially the hardiness of this and all other tender fruit trees.

In 80 counties of the State comparisons were made of the yields obtained from pedigreed seed corn and from the best selected local seed. The pedigreed seed showed an average increase of from 8 to 10 bushels per acre, taking all the trials into consideration.

Experiments are in progress in 92 of the 115 counties of the State, covering the questions of plant adaptation, manurial requirements of different soils, the value of different rotations in different sections, and other questions of like nature. The cooperation with the Department of Agriculture in beef production was terminated, and no additional cooperative work was inaugurated.

The extension work was in the nature of farmers' institutes, Chautauqua lectures, judging live stock, grain, and other products at the county and State fairs, and judging contests at the State, National, and International Live-stock and Grain shows.

Contracts were let for the erection of the new agricultural building and a cold-storage and ice-making plant. The agricultural building is to be located on the horticultural grounds one block from the main campus of the university. It will be 260 feet long and will consist of two stories and a high basement. It is to be constructed of native limestone, thoroughly fireproof throughout, with interior finish of oak, and will cost about $100,000. In addition to the administrative offices of the college of agriculture and of the station, the agricultural library and a commodious reading room, the building will provide laboratories and class rooms for the departments of agronomy and animal husbandry. It will also be used as the headquarters of the State board of agriculture, the State highway commissioner, the State veterinarian, the State dairy and food commissioner, and the State soil survey.

The building will contain an auditorium with a seating capacity of about 500, and with facilities for live stock, dairy, meat, or other demonstrations for use in connection with the farmers' conventions and similar gatherings at the college, and in the basement there will be a large room especially designed for poultry, corn, and dairy shows. It is expected to complete the building by the end of the present fiscal year.

The cold-storage and ice-making plant is to be installed in connection with the dairy building, and will contain rooms of sufficient size to permit of experiments in the storage of butter and other dairy products. It will also be utilized in the handling of the dressed meats of the animals studied in connection with the nutrition investigations under the Adams Act.

Six bulletins were received from this station during the year, as follows: Bulletins 75, Wintering yearling cattle; (*a*) Comparison of different coarse fodders when fed alone, and when combined with a limited grain ration; (*b*) Influence of winter gains upon following summer gains at pasture; (*c*) Efficiency of rations as affected by the season; 76, Fattening cattle for the market: I. A study of the most approved practices in beef production in the corn belt; II. A sum-

mary of some of the feeding experiments conducted at this station; 77, Inspection of commercial fertilizers; 78, Inspection of commercial fertilizers; and 79, Green forage for hogs, a comparison of the feeding value of (*a*) corn and ship stuff; (*b*) corn and alfalfa; (*c*) corn and clover; (*d*) corn and rape; (*e*) corn and bluegrass; (*f*) corn and skim milk.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	16,695.45
Fees	5,262.83
Farm products	9,548.75
Total	55,507.03

A report for the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

Missouri State Fruit Experiment Station, *Mountain Grove.*

PAUL EVANS, *Director.*

The work at this station dealt principally with insects and diseases affecting fruit, particularly apples and peaches. The department of entomology gave much attention to the San José scale. This pest was found to be widely distributed over the State and vigorous efforts were put forth to hold it in check. Spraying demonstrations were conducted in sections where the pest is present, and the results were excellent; in one section where little had previously been done 20,000 trees and shrubs were sprayed as the outcome of the demonstration work. Experiments were also conducted against the codling moth and the curculio infesting the apple. It was shown that arsenate of lead sprays directed against one of these insects could be applied at such a time as to be effective against the other also. An investigation was undertaken dealing with the prevention of injuries to peaches from the curculio and the relation which curculio bears to loss from brown rot.

The plant pathologist undertook a general survey of the various diseases of fruit throughout the State and made considerable progress. Much time was given to the investigation of diseases of the peach and plum, but some attention was also given to diseases of the apple and to blackberry and raspberry diseases.

No publications were received from this station during the year. The income of the station, derived entirely from a State appropriation, was $40,700 for the biennium 1907–8.

MONTANA.

Montana Agricultural Experiment Station, *Bozeman.*

Department of the Montana College of Agriculture and Mechanic Arts.

F. B. LINFIELD, B. S. A., *Director.*

The Montana Station and College are in a most flourishing condition, and the appreciation of their importance in the development of the agriculture of the State is shown by the largely increased State aid. Fully $100,000 has been expended on new buildings, of which the new horse barn is occupied and the new agricultural building is rapidly approaching completion. An appropriation of $5,000 for the purchase of live stock was also made to the station, and its equipment of stock and apparatus is being rapidly extended.

The projects under the Adams fund enumerated in the report for 1907 have been continued with the exception of the one relating to sugar-beet breeding. This was temporarily discontinued at the time the former chemist left the station. The study of seepage waters and the loss of water in canals led up to some very important matters, and the project has been divided so as to include study of cementing material for canals, effect of alkali waters on cement, and removal of seepage water through drainage, and its utilization for irrigation purposes. A preliminary report has been published showing the effect of alkali in soil and drainage waters in disintegrating cement structures, and the most active constituent of the alkali has been determined. Some of the causes of seepage and practical methods for the utilization of seepage waters have been worked out. In the egg-incubation investigations a considerable amount of data regarding the conditions surrounding the incubating egg has been secured. In the studies of diseases of orchard trees and sugar-beet insects progress is reported, and the life histories of some of these pests have been worked out. Progress is noted on all the other projects. A new project has been approved which will consist of a study of some of the factors influencing the quality and quantity of wool production, and work has been begun on the investigatons.

The dairy department is studying the milking machine to determine its efficiency and economic value, the effect of formaldehyde on milk, the melting point of butter, cheese making, testing dairy herd, and effect of water and time at which cows are watered on milk production.

The botanist is studying the distribution of various plant diseases throughout the State and doing some bacteriological work on problems connected with public health. He is also conducting cooperative spraying experiments.

The entomologist is studying a number of miscellaneous problems, among them the spread of oyster-shell bark-louse and means for its control, the life history and hosts of the tick *Dermacenta venustis*, which is believed to transmit the "mountain spotted fever." He is carrying on experiments for the control of many insect pests.

The agronomist is carrying on experiments on rotation of crops, rates and times of seeding, water requirements of different crops, breeding experiments with different crops, and dry-land farming. These experiments are being conducted upon six farms in different parts of the State, over $10,000 having been given to this investigation by the State, railroads, and individuals.

In animal husbandry the department is getting well organized and plans are made for extensive breeding experiments, $5,000 having been spent for live stock within the year. The effect of formaldehyde in milk fed to calves is being investigated, and breeding and feeding experiments with local sheep are contemplated. Feeding and breeding experiments with hogs are in progress.

The horticulturist is testing varieties of small fruits for Montana, collecting varieties of recognized commercial importance, carrying on breeding experiments with fruits and tomato growing. He is also testing introduced and native species of ornamental trees and shrubs, and is carrying on some work on a 20-acre orchard established with State funds in the Bitter Root Valley.

A special dairy train in charge of the dairyman toured the State during May. The train was made up of two box cars fitted up with a milking machine, a pasteurizer, and other dairy equipment, power being supplied by a gasoline engine installed in one car. Four of the best dairy cows at the station were also taken along and used in demonstrations in connection with the lectures.

Five bulletins and the Annual Report for 1906 have been received from this station during the past year. The bulletins were as follows: Bulletins 63, Dry farming in Montana; 64, Fourth annual report of the State entomologist of Montana; 65, Seepage and drainage; 66, An orchard study of the Bitter Root Valley; and 67, Practical beekeeping.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15, 000. 00
United States appropriation, Adams Act	8, 999. 95
Balance from previous year, Adams Act	. 05
State appropriation	10, 886. 58
Individuals	9, 486. 31
Farm products	7, 138. 08
Total	51, 510. 97

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Montana Station is carrying on numerous investigations of great importance to the agricultural interests of the State. The different departments of the station cooperate in a very active and friendly manner, making possible a high degree of efficiency.

NEBRASKA.

Agricultural Experiment Station of Nebraska, *Lincoln.*

Department of the University of Nebraska.

E. A. Burnett, B. S., *Director.*

The past year at this station was marked especially by extensive improvements of the college and station, which were provided for by liberal appropriations by the last legislature. Among the improvements of special importance to the station are a stock and grain judging building costing $30,000 and a veterinary building costing $12,500, which are approaching completion, and greenhouses for work with plant diseases and insects. Other important improvements which have been completed during the year are a $30,000 central heating plant and a $70,000 home economics building. Other extensive improvements of plant (including a plant industry building, new barns, and greenhouses) are planned for the near future. This institution is rapidly acquiring an excellent working plant for both educational and research purposes. (Pl. III, fig. 2.)

An important change in organization during the year was the appointment of E. M. Wilcox, of the Alabama Station, botanist, vice F. D. Heald, who resigned to go to the University of Texas. Several changes were also made in assistants. After the close of the year Martin Nelson, assistant in field crops, resigned to go to the Arkansas Station. E. G. Montgomery, in charge of field crops, was granted leave of absence during the year to do special work at Cornell University.

Considerable progress was made during the year on the Adams fund projects which have been undertaken by the station. Several of the projects were completed and new projects undertaken in their stead. The study of methods of bleaching flour was completed and reported upon,[a] and studies of the cause of "strength" in wheat, including investigations on the relation of the character of the gluten and other factors to the size and quality of the loaf, were substituted for it. The chemist continued investigations on humus and prepared a first report for publication. The study of loco poisoning in horses was temporarily suspended and the results to date were reported.[b]

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[a] Nebraska Sta. Bul. 102.

[b] Nebraska Sta. Rpt., 1907, p. 74.

The production of the disease by the consumption of certain weeds was definitely established and the symptoms and pathology of the disease were quite fully worked out. The veterinarian gave particular attention during the year to studies of tuberculosis in swine as a new Adams fund project. These are carried on in connection with work on centers of infection in the State, which is being done with a State appropriation ($1,000) in cooperation with the Bureau of Animal Industry of this Department, and with the South Omaha stock yards. The first stage of the investigation on the effect of different methods of feeding on the breaking strength of bone in growing pigs has been completed and a report of the work published.[a] It was shown that the strength of bone can be materially increased by supplementing the corn ration with such materials as bone meal, tankage, etc., but whether this will prevent the breaking down of the hind legs of hogs has not been proved. The investigation is to be continued. The soil projects took somewhat more definite form during the year and now include (1) the duty of water from natural precipitation in crop production, and (2) physical and chemical factors which affect nitrification in soils. The horticultural projects were also somewhat more clearly defined and are now as follows: (1) The effect of temperature and soil moisture on winter injury of fruits (apples, peaches, and raspberries), and (2) heredity in plants (beans, pop corn, sweet corn, gourds, and petunias). Important results have already been obtained in the first study. The plant disease investigations took a rather wide range and included studies of corn molds, cedar apple fungus, bitter spot of apples, mold of maple sirup, and other subjects. The present botanist has outlined his work under the Adams fund to include studies of the following subjects: Cherry shot-hole disease, canker of plums, *Trichothecium roseum*, potato stem disease, cedar rust, and minor subjects. Work on the life history of *Diplodia zeæ* was completed soon after the new botanist took charge and the results have been published.[b]

It is evident from the foregoing statement that the station has a large number of Adams fund projects in progress or under consideration. Progress was made during the year in the direction of requiring more definite and permanent lines of work.

In addition to the Adams fund investigations the station continued, and to some extent enlarged, the elaborate system of field experiments which have been carried on for many years. These experiments include improvement of varieties and methods of culture of corn, wheat, oats, barley, and alfalfa, besides various minor crops (macaroni wheat, spelt, forage crops, etc.). Experiments of this kind have been made both at the main station and at the substation at North Platte. The work of the station in introducing winter grains and the adapta-

[a] Nebraska Sta. Bul. 107.

[b] Nebraska Sta. Rpt. 1908.

tion of varieties of corn to different sections of the State through cooperative experiments with farmers has been of great practical value to the State. Cooperative experiments with the Bureau of Plant Industry of this Department in improving wheat and in the study of rotations and methods of tillage at North Platte were continued.

Extensive experiments with beef cattle at both station and substation to determine the most economical use of home-grown feeds in beef production have also yielded results of great practical value. The importance of supplementing corn with more nitrogenous feeds and alfalfa pasture with grain has been shown in experiments with pigs at the station and substation.

The records of the dairy herd, which have been carefully kept for many years, show the importance of selecting animals with reference to "dairy type." It has also been shown that "the cost of butter production can be reduced about 20 per cent by the use of silage as a part of the ration" and "that all dairymen milking 25 or more cows can profitably incur the expense of a silo under such conditions as now exist in eastern Nebraska." The most economical methods of preparing silage have been studied. Tests are being made of the effect of the milking machine on milk and butter production and on the cow's udder. Experiments were also made on methods of feeding calves and the cost of production from birth to maturity.

In horticulture attention was given to experiments in orchard tillage, breeding of apples and peaches (especially for hardiness), crossing wild crab and ordinary apples, growing seed potatoes under mulch, and hill selection of potatoes. Demonstrations of the advantages of spraying were made with State funds in apple orchards in several counties in the State.

Various plant diseases which prevailed during the year received attention. Among these were bud rot of carnations, barley smut, rot of grapes, tomato rots, and a Sphæropsis of apples.

A branch of the Seed Laboratory of this Department was established at the station and considerable work, especially with grass seeds, was done.

By act of the recent legislature an "insect pest and plant disease bureau" has been established at the station. The act carries $7,500 for two years for the work of this bureau. A State fund of $1,000 is also available for the study of plant diseases.

A study of the soils of the State and of soil tillage is in progress.

The equipment and work of the substation at North Platte were enlarged during the year. The improvements there included seed house and soil laboratory, herdsman's cottage, cattle barn and other farm buildings, water systems, machinery, and fencing, costing in

the aggregate about $11,000. The work included experiments with winter wheat (Turkey Red), oats (Kherson), barley, rye, corn, alfalfa, grasses and forage plants, dry-land farming, alkali soils (effect on crops), tree and orchard planting, and feeding of cattle, horses, and swine.

The farmers' institutes of the State are well organized and are supported by a State appropriation of $10,000 for two years.

The publications of the station received during the year were as follows: Bulletins 99, Growing hogs in western Nebraska; 100, Economical rations in beef production; 101, Dairy herd record for ten years; Cost of butter-fat production; 102, The effect of bleaching upon the quality of wheat flour; 103, The bud-rot of carnations; A mite accompanying the bud-rot of carnations; 104, Cultivation of small grains; The use of the fanning mill for selecting seed wheat and seed oats; 105, Growing cattle in western Nebraska; and 106, Does it pay to spray Nebraska apple orchards?

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation for substation	[a] 15,000.00
Farm products	23,711.80
Balance from previous year	5,304.37
Total	68,016.17

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Nebraska Station continued during the past year to make notable advance in the improvement of its material equipment, in the development of its scientific investigations, and in the extension of the benefits of its practical work. Public appreciation of its work is evidenced by steadily increasing appropriations to the institution by the State.

NEVADA.

Nevada Agricultural Experiment Station, *Reno.*

Department of Nevada State University.

J. E. Stubbs, D. D., LL. D., *Director.*

As in previous years, the work of the Nevada Station was largely devoted to questions of farm practice, dealing especially with the adaptation of crops to the peculiar soil and climatic conditions of the State.

Of the Adams fund projects already reported, the breeding work with alfalfa (Pl. IV, fig. 1) and the meteorological and climatological

[a] Balance of appropriation of $25,000 for biennium ending March 31, 1909.

FIG. 1.—ALFALFA-BREEDING PLATS, NEVADA STATION.

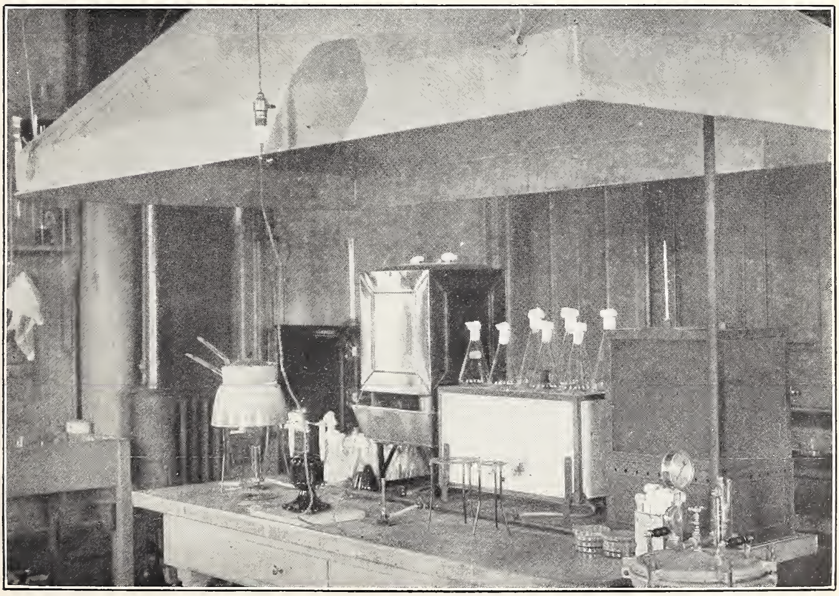

FIG. 2.—STERILIZING TABLE AND HOOD, VETERINARY AND BACTERIOLOGICAL LABORATORY, NEVADA STATION.

studies on Mount Rose were continued and the following new projects were started: A study of the native clovers; the influence of soluble salts in the soil on native plant growth; parasitism of the codling moth; study of a fatal disease among horses; study of the food of Aphidia and Inocellia with special reference to their relation to the codling moth. (Pl. IV, fig. 2.)

The department of agriculture and animal husbandry carried on work in cooperation with this Office in irrigation investigations. The results emphasize the fact that in ordinary irrigation practice in Nevada fully twice as much water is used in the growing of crops as is needed for the best results. In no case did the plats receiving the most water give the best yield. The department continued work relating to the production of milk and butter fat; swine breeding, with a view of producing a type of Berkshire adapted to western grazing conditions; and production of winter lambs.

In addition to its work on Adams fund projects, the department of entomology made some investigations of the elm scale.

The chemist made soil-fertility tests on the Hazen bench of the Truckee-Carson project, and cooperated with the botanist in digestion experiments with native grasses and forage plants and in work on the chemical composition of native forage plants; the latter has been discontinued for the present.

The department of veterinary science and bacteriology began a study of avian tuberculosis and continued, in cooperation with the botanist, the work on fire blight in fruit trees.

The department of botany and horticulture carried on a study and collection of the flora of the State, especial attention being given to the grasses and other plants and shrubs of forage value, and investigations on physiological and pathological diseases of plants. Orchard studies and demonstration were made on the culture, care, and irrigation of suitable varieties of fruits for the conditions prevailing in Nevada; and ornamental trees suitable to the conditions in western Nevada, ornamental shrubs and perennial flowering plants and the introduction of native plants of probable horticultural value were studied in the arboretum and the botanical garden.

The only publication received from this station during the year was the Annual Report for 1906.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15, 000. 00
United States appropriation, Adams Act	9, 000. 00
Local community and individuals	388. 55
Farm products	248. 05
Miscellaneous	1, 119. 32
Balance from previous year	1, 164. 25
Total	26, 920. 17

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

NEW HAMPSHIRE.

New Hampshire College Agricultural Experiment Station, *Durham.*

Department of New Hampshire College of Agriculture and Mechanic Arts.

E. D. Sanderson, B. S. A., *Director.*

The past year was the first of this station under a separate directorship, E. D. Sanderson, formerly entomologist of the station, taking charge as director at the beginning of the fiscal year. A number of changes in organization occurred during the year. The horticulturist, H. F. Hall, resigned to go into private business, and was succeeded by B. S. Pickett, of the Illinois Station. A dairyman, R. Rasmussen, of the Iowa Station, was appointed. During the year the station was relieved of certain commercial features of the horticultural work, these being assumed by the college. Agronomy and animal husbandry were made separate departments, F. W. Taylor being placed in charge of the former and W. H. Pew of the latter. Professor Pew has been relieved to a considerable extent of college duties, so that he may concentrate attention on the large sheep-breeding project of which he has charge. Other appointments on the station staff during the year included C. F. Jackson, of Ohio State University, assistant entomologist, vice C. S. Spooner; I. M. Lewis, of the University of Idaho, assistant botanist; W. H. Wicks, of the Oregon Station, assistant horticulturist; J. C. McNutt, herdsman; and David Lumsden, assistant in floriculture.

Work was continued on the six Adams fund projects enumerated in last year's report. Some of the projects were slightly modified, and work on one, viz, the codling-moth investigations, was practically completed. It is to be replaced by studies on the apple maggot. In general it may be said that good work has already been done on several of the projects and all seem to be assuming satisfactory shape.

In addition to these investigations, the work in agronomy included breeding of a dent corn to replace the flint corn commonly grown in New Hampshire; tests of varieties of corn, oats, and barley; fertilizer experiments with hay grasses on plats formerly used in rotation experiments and now used in studies of availability of potash; and cooperative tests of alfalfa.

Work in the breeding and crossing of vegetables, especially squashes, tomatoes, and cucumbers (Pl. V); on seedling strawberries; and on varieties of lettuce was continued. Some good crosses of squashes for market purposes have been secured and are ready for

FIG. 1.—HOUSE OF GRANITE STATE CUCUMBER, GROWN FOR SEED, NEW HAMPSHIRE STATION.

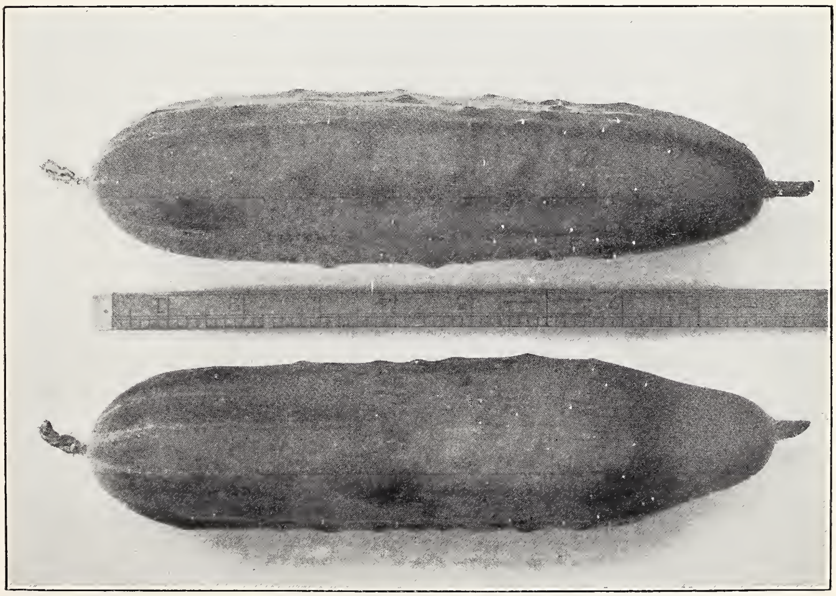

FIG. 2.—GRANITE STATE CUCUMBER, ORIGINATED BY NEW HAMPSHIRE STATION.

Cross of Telegraph × White Spine × White Spine.

distribution. Methods of culture and varieties of strawberries suited to New Hampshire were reported on during the year.

The dairyman made a survey of methods of home butter making in the State, with a view to suggesting improvements, and tested cows for advanced register. The station does not have satisfactory facilities for experimental work in dairying.

The botanists made comparative tests of standard and proprietary Bordeaux mixtures and other fungicides, and experiments with lime-sulphur wash at different places in the State in cooperation with the Bureau of Plant Industry and in spraying to destroy weeds. They also made some studies of mushrooms and made collections of parasitic fungi.

The chemist gave attention to studies on humus soil, acidity, etc. He completed and reported during the year a study of respiration in apples in its relation to their keeping, which explains the relation of temperature to respiration and keeping in apples. He also reported a study of humus in New Hampshire soils and its relation to fertility. The chemical department continues to do the analytical work connected with the State inspection of fertilizers and feeding stuffs. This involved in 1907 analyses of about 50 samples of feeding stuffs and 100 samples of fertilizers which were reported with brief discussion.

In compliance with a resolution of the governor and council, the director prepared a report on the gipsy and brown-tail moths in New Hampshire, which was published. He also made studies on the striped cucumber beetle.

The following publications were received from the station during the year: Bulletins 129, Annual reports for 1905 and 1906; 132, A plan for improving the quality of milk and cream furnished to New Hampshire creameries; 133, The inspection of feeding stuffs in 1907; 134, Fertilizer analyses; 135, The respiration of apples and its relation to their keeping; and 136, The gipsy and brown-tail moths in New Hampshire.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Fees	1,616.96
Farm products	377.50
Total	25,994.46

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The New Hampshire Station has made notable progress during the year in strengthening its organization and work.

NEW JERSEY.

New Jersey State Agricultural Experiment Station, *New Brunswick.*

At Rutgers College.

E. B. Voorhees, D. Sc., *Director.*

New Jersey Agricultural College Experiment Station, *New Brunswick.*

Department of Rutgers College.

E. B. Voorhees, D. Sc., *Director.*

The work of the New Jersey stations, as in the past, has been largely a continuation of the lines of investigations already established. The State Station has charge of the inspection work and analysis of fertilizers, feeds, and Paris green, as well as the work connected with mosquito eradication in the department of entomology. An increased interest is manifested, both on the part of the farmers in the results of the analyses made and bulletins issued, and of the citizens of the State in the improvement of salt-marsh areas.

The work under the Adams Act in vegetable breeding and the chemistry and bacteriology of soils has been steadily prosecuted along the lines outlined in the report for 1907. The facilities for this work have been greatly enlarged. The area devoted to plant breeding has been increased to 8 acres. More than 100 permanent plats of one-twentieth of an acre each have been established for the study of the chemical, biological, and physiological effects of fertilizers and green manures, including both cereals and legumes. Much time has also been devoted to a study of methods for the differentiation of bacteriological reactions in the soil. New methods have been devised, which promise to be an aid in investigations of this character.

In the horticultural department the work on the home grounds has been continued as heretofore. The experiments with tree fruits and berries are especially interesting and valuable, the fertilizers showing a marked effect both in the yield and quality of the fruit.

An additional cooperative experiment on peaches and also cooperative experiments with grapes have been begun at Vineland. The results of this work bring out many new features which are of great importance in the development of the fruit industry. Much time has been given to a study of the peach yellows, which is found in scattered localities.

New experiments have been planned for the greenhouse, to study the question of rose and carnation growing; the culture of these flowers under glass is a very important industry in this State, and many problems of soil and fertilizers need to be solved.

In the animal husbandry department an entirely new herd has been purchased, which includes a number of specimens of the four

leading dairy breeds, as well as grades. In addition to the study of milk production much attention is now being given to the selection of animals and to breeding. Plans have also been made for experiments in growing pigs for early market.

The study of soiling, forage crops, and farm management has also been continued with very striking results, the continuation of the work for a series of years showing the very great advantage of continuous cropping and the judicious introduction of leguminous plants. The yields of hay, forage, and alfalfa are averaging larger each year under the system adopted.

Through the cooperation of the farmers of the State, experiments have been conducted upon sandy soils, which show very striking results as to the advantages of the use of mineral fertilizers and green manures, in addition to the cooperation already mentioned in growing peaches and grapes. Work has also been started, through the cooperation of the farmers, for a series of demonstration experiments upon farms in Cumberland County.

In the department of entomology studies have been made of strawberry insects, and practical methods of control now seem available. Cranberry insects have also been studied, notably a cutworm, a flea-beetle and long-horned grasshopper. Work on the root maggots of cabbage and onions has been continued. Considerable time has also been devoted to the testing of insecticides against scale insects, all of which has a practical bearing upon the development of the fruit industries of the State. The station favors commercial preparations of insecticides as being more convenient and as a rule more reliable. Good progress has been made in the mosquito work. The drained area now extends well down the coast.

In the department of biology the investigation of oyster propagation has been continued with largely increased facilities, and much progress has been made in this important branch of the station's work.

The station is encouraging the formation of demonstration associations in different parts of the State. These are voluntary associations of farmers and horticulturists, who employ an expert agent to conduct demonstration fields or plats. The station acts in an advisory capacity, but does not pay the expenses of this work.

Buildings have been erected for the short-course work of the college. These are located on a piece of new land on the farm and constitute a substantial addition to the college equipment. The main building contains rooms for a working dairy, soils laboratory, class rooms, assembly hall, museum, etc. There are also two greenhouses with workrooms attached. These are in addition to the barn and stock-judging referred to in the previous report.

Dr. K. C. Davis is now in charge of the short course and extension work of the college and has his headquarters at the building on the farm. He expects to get in close touch with schools throughout the State and promote the introduction of instruction in agriculture in high schools. It is expected that the new equipment will increase the number of students in the four-year course in agriculture.

The publications received from the stations during the year were as follows: Bulletins 203, Some household pests; 204, Home-grown protein versus purchased protein, Distillers' grains versus gluten feed, Summer silage versus soiling; 205, Analyses of Paris green; 206, Analyses and valuations of commercial fertilizers, Analyses of fertilizer supplies, home mixtures, and special compounds; 207, The New Jersey salt marsh and its improvement; 208, Analyses and valuations of commercial fertilizers and ground bone; 209, Novelties in vegetable fruits; 210, Some chemical and bacteriological effects of liming; 211, Sandy soils and their improvement in the growing of forage crops; and 212, Concentrated feeding stuffs; and the Annual Reports for 1906 and 1907.

The income of the stations during the past fiscal year was as follows:

State Station: State appropriation (fiscal year ended October 31, 1908)	$45,000.00
College Station:	
United States appropriation, Hatch Act	15,000.00
United States appropriation, Adams Act	9,000.00
Total	69,000.00

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The work of the New Jersey stations has a steady growth and each year a wider appreciation of the practical value of the work is manifested.

NEW MEXICO.

Agricultural Experiment Station of New Mexico, *Agricultural College.*

Department of New Mexico College of Agriculture and Mechanic Arts.

LUTHER FOSTER, M. S. A., *Director.*

At the close of the academic year the director retired from the presidency of the college in order to devote his entire time to the direction of the station activities. He was succeeded as president by Dr. W. E. Garrison. J. J. Vernon, who had been agriculturist of the station for eight years, resigned at the end of the fiscal year and took a similar position at the University of Florida. Numerous

changes of assistants took place during the year, and an assistant in botany was added to the staff.

The nutritive effect of certain feeds in the production of beef from range steers was discontinued as an Adams fund project, the cattle having been sold. Some progress was made on all the other investigations under the Adams fund as outlined in the previous report, but unforeseen difficulties interfered to quite an extent with certain projects. With the cactus this was due to the unlooked-for destruction of the plants by rabbits and field rats, the plants being considered capable of protecting themselves; and with the rubber plants it was found very difficult to secure seeds and tubers, and this fact necessarily delayed the work. During the year an extensive out-door laboratory for studying problems in irrigation of crops was completed. The delay in beginning this experiment was due to the large amount of work involved in the construction of the well and distributing system and the installation of the pumping plant. The construction work gave a large amount of experience in establishing a pumping plant under adverse conditions, arising from an excessive amount of quicksand in the water-bearing formation. This later proved valuable as a basis of advice to prospective builders of such plants.

The investigation of the digestibility of prickly pear cactus in cattle feeding was completed, and some progress was made in the study of the coloring matter of the cactus fruit and in the chemistry of the plant. The results of the cactus-feeding experiments show the digestibility of the prickly pear to compare favorably with that of other cattle feeds, and also show that it will increase the digestibility of dry coarse fodders. Its feeding value proves about equal to that of sugar beets. The progress made in the study of the codling moth and grape-crown gall was very satisfactory, while that made in the improvement of Mexican chile was interfered with by a disease that killed many of the plants. A new project outlined is an investigation of pumps of different styles, to determine the reason for apparent differences in performance due to unusual forms of design and construction, and the sources and reasons for energy loss.

Besides Adams fund work the botanist carried on a study of native plants as ornamentals, and continued work on forage plants and the compilation of data for a bulletin on the weeds of the Territory.

In horticulture a pruning experiment for the prevention of sun scald on peach trees was carried on. The new vineyard was kept up, and it is proposed as soon as the vines begin to bear to investigate the keeping qualities of different winter varieties and to test the stump method of pruning as compared with the trellised system. A new apple orchard consisting of 48 varieties was started. Variety

tests of strawberries were made, and experiments with onions, celery, and sweet potatoes were continued. It was found that the use of either commercial fertilizer or barnyard manure increased the yield of onions 33⅓ per cent. Sweet potatoes were shown to keep best in the climate of New Mexico when stratified with sand. It was also shown that vine pruning to increase the yield of sweet potatoes is a fallacy. Lime-sulphur solution proved effective in destroying San José scale.

The work of the chemist was chiefly on Adams fund projects, but he also began a study of the production of alcohol from the tuna.

The agriculturist continued variety tests of field crops, made investigations of the time of planting field crops, and carried on an experiment with cantaloups, including cultural methods, yield, waste, and expense. New investigations included plant selection for the purpose of developing crops better suited to dry farming and irrigation districts, and rotation of field crops and fertilizing to establish a system of maintenance of fertility.

The following lines of work were carried on in animal husbandry and dairying: Feeding experiments with dairy cows to determine the comparative value of bran and cotton-seed meal when fed with corn meal and alfalfa hay; the comparative value of Bermuda and Johnson grass pastures for dairy cows; breeding comparisons of poultry as to costs and results and a study of egg production; and the carrying capacity of alfalfa pastures for horses. In the dairy feeding experiment the cotton-seed meal proved of greater value than wheat bran when fed in connection with corn and alfalfa. It was also shown that much loss may result from overfeeding dairy cows with alfalfa hay, and also that large rations do not give the best results either economically or in quantity.

Phenological fruit work and grape crown gall investigations and an experiment with seed furnished to ten farmers in the Estancia Valley were carried on in cooperation with the Bureau of Plant Industry of this Department. The object of this experiment was to test the drought resistance of two varieties of wheat and one of oats, and to ascertain if a strain of milo maize would mature at an altitude of 6,000 feet. For the determination of soil evaporation under the same cultural and moisture conditions as those existing on the irrigation plats, a series of tank experiments has been inaugurated, and the work is being carried on in cooperation with the irrigation investigations of this Office. The starving out of the codling moth was carried on in cooperation with the orchardists of the Mesilla Valley. The results indicate two full broods of the codling moth and a partial third. Observations in the absence of all kinds of fruits indicate that the codling-moth larva will not mature on either the

apple leaf or twig, but that the pear twig does furnish sufficient material for its full maturity.

An agent was kept in the field during seven months of the year, his time being largely devoted to farmers' institute work. He visited 17 of the 25 counties in the Territory, stopping at 64 towns and villages. Seventy institute sessions were held, the total attendance amounting to 3,685 persons. Much interest was shown in this work, and the people became more familiar with the work of the experiment station. In addition to holding meetings, much information was gathered regarding the agricultural conditions in the various localities, which has been of much assistance to the station workers in enabling them to answer properly the numerous inquiries that have come in, especially from the newly settled portions.

The following publications were received from this station during the year: Bulletins 62, Pig feeding; 63, Melon culture; 64, The tuna as a food for man; and 65, Codling moth investigations, and the Annual Reports for 1906 and 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Fees	77.75
Farm products	3,922.29
Miscellaneous, including cooperative receipts	616.67
Balance from previous year	231.55
Total	28,848.26

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

No Territorial appropriation has ever been made for the direct use of the station, but during the past year the station funds were supplemented by several thousand dollars of the Territorial fund. Considering its resources and the conditions attending its work, the New Mexico Station makes a very creditable showing. The irrigation investigation, in particular, gives promise of results of value to the entire arid and semiarid region.

NEW YORK.

New York Agricultural Experiment Station, *Geneva*.

W. H. JORDAN, D. SC., *Director*.

The work of the New York Station progressed steadily during the past year under the same policy of administration, and mainly along the same lines as heretofore. There was no material change in equipment during the year, but the station received a State appropria-

tion of $32,500 for the erection of four dwellings for members of the staff and a laborer's cottage. The State appropriation for maintenance was somewhat larger than formerly.

Progress was made on both the projects to which the Adams fund, supplemented by State funds, is being devoted. The elaborate study of the bacterial flora of cheese is nearing completion. The important study of the metabolism of mineral nutrients by milch cows is being continued.

Bacterial studies of the soft rots of vegetables included examinations of both plants and soils. An investigation of milking by machine, with special reference to the control of the germ content of the milk, gave some interesting and practical results.

With poultry, feeding experiments were made with special reference to the importance of mineral nutrients and the experiments in selection and inbreeding continued.

Among the chemical studies were an extensive investigation of the changes taking place in the souring of milk and the development of a simple volumetric method for the determination of casein in cow's milk.

In botany there was a comprehensive study of the diseases of alfalfa, on which it is expected to issue a report at an early day. A currant-cane blight and the Sphærella wilt of melons were also studied. Seed examinations for purity are increasing in number.

Among entomological studies were those on apple canker, cabbage rootworms, and the grass mite on carnations; on the control of the blister mite; and spraying trees in foliage with sulphur washes and various sprays for the destruction of aphis eggs.

The horticultural department has issued the great monograph on the grapes of New York. In this about 1,000 varieties are described, and it is handsomely illustrated with colored plates. It is planned to make this the basis for breeding grapes. Breeding experiments with orchard and small fruits and vegetables are being made on quite a large scale, the main object being to get light on principles of breeding. Experiments with fertilizers for fruit trees, sod mulches, and the like, were continued in orchards in several localities.

In agronomy the work included studies on the advantages of various systems of fertilization and green manuring on field crops grown in rotation, and tests of sugar beets with reference to seed production and development of superior strains.

The large control service is being performed as heretofore.

Cooperative work with farmers is growing in importance, and includes experiments with dwarf apples, resistant stocks for vines, inoculation and liming of alfalfa, potato spraying, control of San José scale and blister mite.

Cooperation with this Department in a study of the Hessian fly and experiments with sugar-beet seed was continued.

In publications recently issued the following results have been announced: The securing of several new varieties of raspberries and strawberries, the necessity of inoculation in a large proportion of the soils of the State before growing alfalfa, the marked protection of cabbage-seed patches against the cabbage maggot by muslin shading, the benefit of sulphur sprays for the blister mite, the practicability of controlling the San José scale in old orchards, and the inadvisability of dipping nursery stock in insecticides.

The following publications were received from this station during the fiscal year: Technical Bulletins 5, Chemical studies of Camembert cheese; and 6, Chloroform as an aid in the study of milk enzyms; Bulletins 289, The effect of wood ashes and acid phosphate on the yield and color of apples (with popular edition); 290, Potato spraying experiments in 1906 (with popular edition); 291, Inspection of feeding stuffs; 292, Effect of treating milk with carbon-dioxid gas under pressure (with popular edition); 293, Analyses of miscellaneous materials; 294, Report of analyses of samples of fertilizers collected by the commissioner of agriculture during 1907; 295, Director's report for 1907; 296, Control of scale in old apple orchards (with popular edition); 297, Investigation on some fruit diseases. I, Apple rots in cold storage. II, Peach rot in cold storage. III, Sulphur fumigation to destroy apple rot fungi. IV, Apple injury by sulphur fumigation. V, Enlargement of apple-scab spots under a covering of Bordeaux mixture (with popular edition); 298, Distribution of station strawberries and raspberries; 299, The relation of weather to the setting of fruit, with blooming data for 866 varieties of fruit; 300, Inoculation as a factor in growing alfalfa (with popular edition); 301, Screening for the protection of cabbage seed beds (with popular edition); and 302, Dipping of nursery stock in the lime-sulphur wash; Circulars 6, The renovation of worn-out orchards; and 7, The "King system" of stable ventilation; and the Annual Report for 1906.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$1,500.00
United States appropriation, Adams Act	900.00
State appropriation	86,595.63
Balance from previous year	8,324.45
Total	97,320.08

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The New York Station is in a prosperous condition, is doing a relatively large amount of scientific work, is performing control service

efficiently, and is extending its more practical operations, particularly as regards the orchard and small fruit plantations at Geneva and the work in horticulture and plant diseases conducted in different parts of the State.

Cornell University Agricultural Experiment Station, *Ithaca.*

Department of New York State College of Agriculture at Cornell University.

L. H. Bailey, M. S., *Director.*

During the past year the Cornell College and Station entered more fully on the development of educational and research work in agriculture along the general lines reported in 1907. It is the present policy to use the Federal funds for the station mainly for the maintenance of researches in the departments of soils and plant breeding and to supplement these with State funds for experimental inquiries conducted through the other departments of the college of agriculture. Much time was necessarily devoted during the past year to the formulation of plans and the equipment of the new buildings, and it was therefore not possible to engage in experimental work as broadly as it is hoped to do hereafter.

The plan of work under the Adams Act, as outlined in the report for 1907, was continued. This includes investigations mainly in plant breeding and soil physics and chemistry, together with a limited entomological study of insects infesting timothy grass. The soils laboratory was thoroughly equipped, and a system of cement tanks for soil cultures was constructed (fig. 1.) A considerable area of land was set aside for the work in plant breeding, and laboratories for this department were equipped. Two small greenhouses for work in soils and plant breeding are in operation, and more extensive greenhouses will be erected within the next year. Considerably more than the Adams fund is being spent on the enterprises to which that fund is devoted.

Experimental work along most of the lines mentioned last year was continued, and among other studies were the following: Studies of insects affecting rhododendrons and other ornamental shrubs and trees, the moisture and sulphur dioxid content of dried apples, field and laboratory investigations on the black rot of grapes, the influence of shade on plants, stimulation tests with plants, studies in market milk supplies, the effect of vegetable color on flavor of butter, causes of bitter cream, leaf blight of tomatoes, and loose smut of wheat. The study of peonies became quite extensive and included an investigation of diseases. The surveys of the conditions of soils, field crops, and fruits in various parts of the State were extended and in certain areas the general economic status of farms was studied. Much of this work involved cooperation with farmers and there were also

many demonstration plats maintained on farms. Cooperative work with this Department was conducted in the study of the little peach

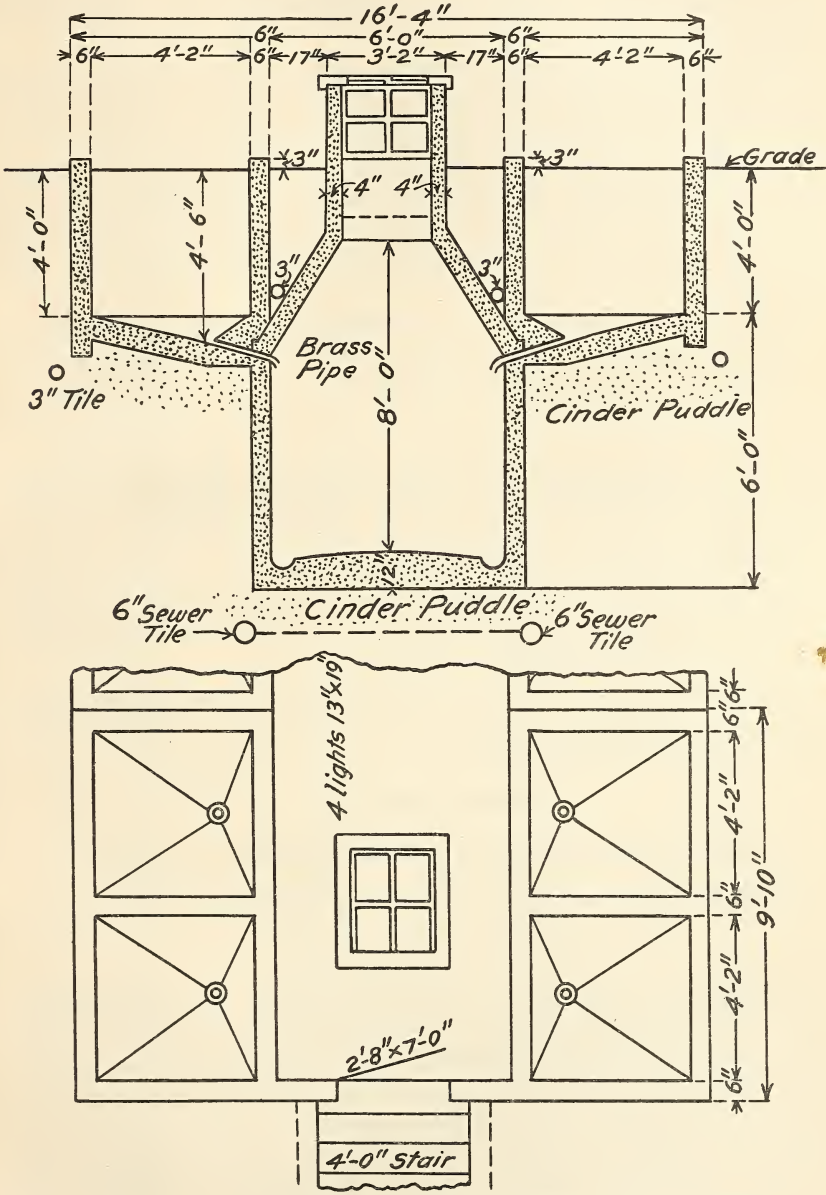

FIG. 1.—Concrete tanks for soil investigation, New York Cornell Station.

disease, soil surveys, plant-breeding investigations, and the collection of data concerning plant diseases.

The extension work of the college is steadily increasing and is more thoroughly and distinctly organized. It includes correspondence, reading courses, propaganda and advisory work in the schools, lectures, holding of meetings, and neighborhood work conducted by students.

The publications received from this station during the fiscal year were as follows: Bulletins 246, A gasoline-heated colony brooder house; 247, The importance of nitrogen in the growth of plants; 248, New poultry appliances; 249, Comparison of four methods of feeding early hatched pullets; 250, Bovine tuberculosis; 251, Plant breeding for farmers; 252, Insect pests and plant diseases; and 253, The black rot of the grape, and its control; and the Annual Reports for 1906 and 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$13,500.00
United States appropriation, Adams Act	8,100.00
Total	21,600.00

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The State appropriated $150,000 for the maintenance of the college in 1908, and $10,000 for its demonstration and other extension work. No new buildings were erected last year, but $25,000 has been provided for barns and $30,000 for greenhouses.

Both college and station are in more prosperous condition than ever before and are doing a larger amount of work in education and research along most useful lines.

NORTH CAROLINA.

North Carolina Agricultural Experiment Station, *West Raleigh.*

Department of North Carolina College of Agriculture and Mechanic Arts.

C. B. Williams, M. S., *Director.*

The past was the first year of this station under the new organization, whereby the management of the station was taken from the State board of agriculture and vested in a distinct board of control. The withdrawal of the State board of agriculture from cooperation, with the organization of a separate experiment station, resulted in a complete reorganization of the college station, with the abandonment of some former lines of work and the inauguration of several new lines.

It was necessary to concentrate the experimental work almost exclusively at the station, cooperative and other work in the State at large being cared for by the station of the board of agriculture, which

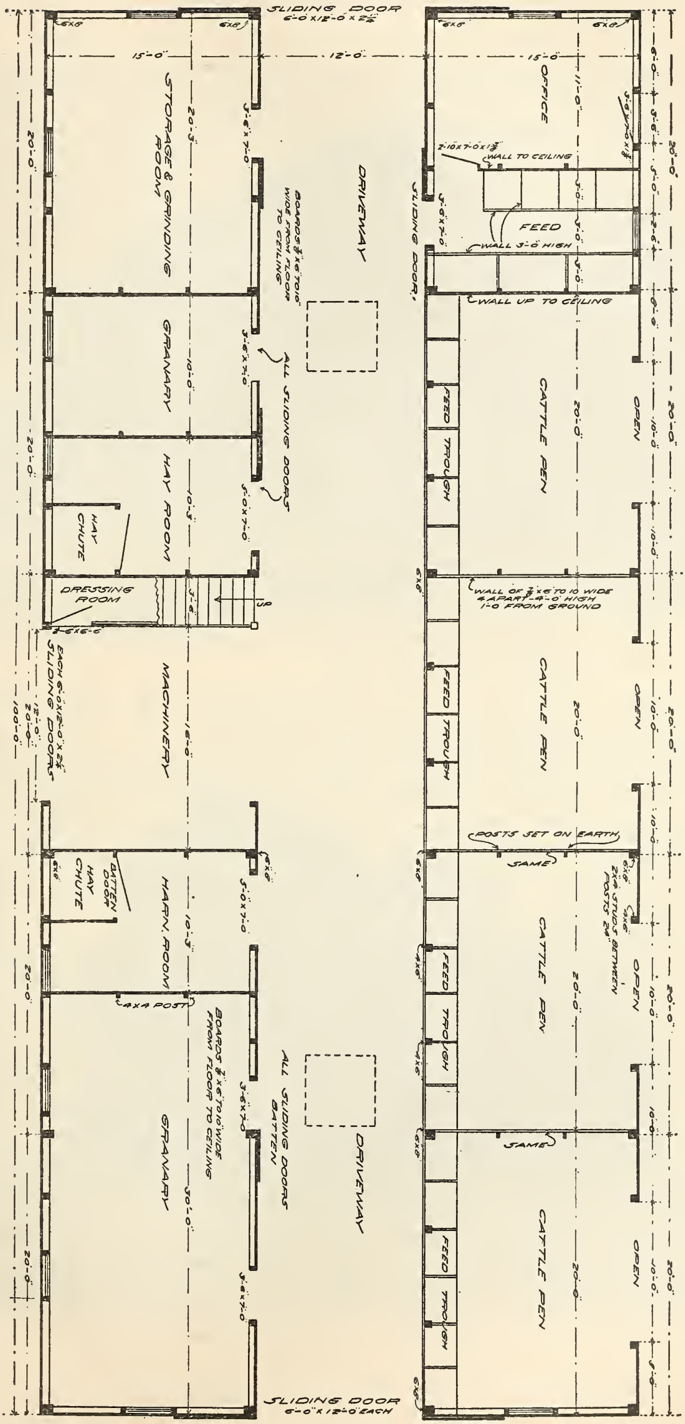

FIG. 2.—Floor plan of new barn, North Carolina Station.

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is well equipped for such work through its series of four experimental farms and the liberal funds at its command for this purpose.

The station has set apart for its use from the college farm 200 acres of land, but has had a poor equipment of farm buildings and greenhouses. One of the station barns and the manager's house were destroyed by fire May 25, 1908. A new and larger barn has been built (Pl. VI and fig. 2). The departments which have been organized now include agronomy, horticulture, animal husbandry, dairy husbandry, poultry raising, chemistry, plant pathology, and entomology. All of these are well established, although some of them have been but recently organized, and the station would now seem to be in a position to develop and strengthen its work along the more advanced lines of agricultural investigation.

Several new Adams fund projects were undertaken during the year, and some of the older projects were more clearly defined. The former include cause of development of suckers on corn, and their relation to prolificacy and total yield, "double flower" in blackberries and dewberries, and ptomaines in milk and cream. Work was successfully prosecuted along the lines originally laid down on organisms and processes involved in fixation and transformation of nitrogen in the soil and on apple and lettuce diseases, particularly leaf spot and canker of apples and lettuce drop.

The more important features of the work of the station outside of Adams fund projects are in brief as follows:

Selection and breeding of cotton, corn, and wheat, and incidentally of a few other crops; variety, fertilizer, and culture tests of cotton, corn, wheat, oats, cowpeas, soy beans, and potatoes; studies of grass combinations for grazing and for hay; and comparison of different kinds of clovers (including alfalfa). Special attention is given to cotton and corn.

Extensive plantations of blackberries and dewberries were made and were used, in addition to investigations on "double flower," for variety and fertilizer tests and studies of self-sterility. Experiments were made on the best methods of cutting back blackberries and dewberries for protection against disease, some cooperative work in this line being done at Cameron on a commercial plantation. Experiments on figs, pecans, and Scuppernong grapes are also in progress.

Experiments with cotton-seed meal and corn rations and with green crops for hogs, and with corn and cotton-seed meal rations for horses and mules, were carried on in the department of animal husbandry. Hog yards were built on the station farm during the year and data collected by letters of inquiry from swine breeders throughout the State.

FIG. 1.—FRONT VIEW OF NEW BARN, NORTH CAROLINA STATION.

FIG. 2.—REAR VIEW OF NEW BARN, NORTH CAROLINA STATION.

In dairy husbandry attention was given especially to the study of methods of handling and marketing milk and cream, the feeding of calves, and the feeding of milch cows. Several cheap and practical methods of cooling milk were worked out, and a cheap substitute (based largely on the use of oatmeal) was found for milk for feeding calves. In the feeding of cows good results were obtained with rations of corn meal, cotton-seed meal, and brewers' grains, with shredded-corn stover. Tests were also made of cotton-seed hulls as roughage. Methods of sterilizing dairy utensils, especially bottles, adapted to small dairymen, were studied.

In poultry raising some attention was given as heretofore to breeding, feeding, incubation, and brooding. The only new feature introduced was tests of cotton-seed meal as a feed for hens.

The chemist's time was devoted almost exclusively to the chemical work involved in the Adams fund project on fixation and transformation of nitrogen in soils, but he also did the analytical work required by other departments of the station.

In plant pathology attention was given as heretofore to the study of melon, tobacco, and potato wilt, and breeding for wilt resistance. Other diseases appearing during the year, notably on vetch, alfalfa, maple, etc., also received some attention. The station continued cooperation with the Bureau of Plant Industry of this Department in a plant-disease survey of the State and in breeding work with watermelons.

The entomologist has been occupied mainly with the collection of information regarding nature and remedies for garden insects important in North Carolina, and with studies of life history and means of repression of plum curculio, cabbage harlequin bug, cabbage webworm, cabbage aphis, corn weevils, peach-tree borer, and red ants.

The following publications of the station were received by the Office during the year: Bulletins 195, Farm poultry, and 196, Some apple diseases, and the Annual Reports for 1905, 1906, and 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Farm products	1,073.41
Miscellaneous	636.54
Total	25,709.95

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The North Carolina Station is wholly dependent upon Federal funds for its support. In view of the restrictions surrounding the use of these funds, a supplementary State appropriation under less restriction is essential to the highest efficiency of the station.

Agricultural Experiment Station of the North Carolina State Department of Agriculture, *Raleigh.*

B. W. Kilgore, M. S., *Director.*

At the North Carolina State Station the principal lines of work are the same as heretofore, and relate to chemistry, soils, field experiments, horticulture, diseases of domestic animals, entomology, cooperative demonstration work with farmers, fertilizer experiments and fertilizer analyses, inspection of human foods and stock feeds, and farmers' institutes. Among the important lines of experimentation are those to determine the plant-food requirements of different type soils, conducted at the branch stations located on type soils in different parts of the State, and tests of varieties of crops which succeed best on those soils.

Considerable cooperative work is being done with farmers in the testing and introduction of new varieties of cotton, corn, and oats, using mainly seeds which have been produced at the branch stations on the type soils. Work of a similar nature is being done in pruning, spraying, and packing fruit.

Cooperative work is carried on with the Bureau of Plant Industry on the Scuppernong grape at the Pender branch station. This work has been in operation for three years and includes a planting of all varieties of this grape which have been collected in the Atlantic coast States, together with methods of training, pruning, fertilizing, and cultivating. Work is being done in cooperation with the Bureau of Animal Industry in the extermination of the cattle tick. Satisfactory and gratifying progress is being made in this work.

An additional substation, the fifth, has been established at Black Mountain. The income of the North Carolina State Station is approximately $60,000, of which about $5,000 is derived from the sale of farm products and the balance comes from the tonnage tax on fertilizers and stock feeds.

The results of the work of this station are published in the Bulletin of the North Carolina Department of Agriculture, of which 12 numbers appear annually. Those issued during the fiscal year ended June 30, 1908, contained reports on fertilizers and fertilizer inspection; food inspection; stock feeds; dewberries; lettuce growing in North Carolina; farmers' institutes; bee keeping in North Carolina; variety, fertilizer, and distance tests with corn and cotton; and composts versus fertilizers for tobacco.

NORTH DAKOTA.

North Dakota Agricultural Experiment Station, *Agricultural College.*

Department of North Dakota Agricultural College.

J. H. Worst, LL. D., *Director.*

The North Dakota Station has had a steady development during the past year largely along lines previously noted. A number of additional assistants has been secured with a view to relieve the station workers from teaching.

The station has erected a grain and seed barn, at a cost of about $9,000, and a machine barn that cost a little over $2,000. Both are in use at this time. Three new greenhouses are in the course of construction. Two of the new greenhouses are 66 by 18 feet each and the other is 66 by 24 feet; they will add very greatly to the equipment of the departments of horticulture and botany.

The investigations inaugurated under the Adams Act, which consist of four projects for the department of botany and two for the department of chemistry of the station, have been continued along the lines given in the report for 1907. The botanist has pursued studies on the underlying principles of resistance to disease, the effect of fertilizers on the structure and physiology of the host plant, and the relationship of soil organisms to crops, and he has an extensive series of experiments running with each project. The study of resistance to disease has required an investigation of the organisms causing disease, and the life histories of a number have been more or less completely worked out. The laboratory facilities and equipment have been greatly extended, so that the work can proceed in a more satisfactory manner. In the chemical department extensive studies have been made of the milling qualities of wheats grown under varying conditions, and chemical and baking tests have been made of the different flours. A large number of soil analyses has been made as preliminary to further work on the nutrition of the wheat plant and its relation to soil conditions. A new project on the nature and etiology of swamp fever in horses has been approved.

The botanist has been carrying on some weed-eradication experiments with various chemicals and has had success with spraying a solution of iron sulphate on mustard and dandelions. He is also continuing his investigations on smuts of grain and means of control, and making a number of preliminary experiments, such as seed testing, forage plants, poisonous plants, close fertilization of clover, and plant diseases. Artificial feeding of trees transplanted out of the usual season was successfully done this season. Considerable loss was met with in the flax-breeding experiments by a severe hailstorm

early in September. Nearly all the seed of some of the resistant types was lost.

The horticulturist is carrying on a number of experiments in variety testing, adaptation tests, plant breeding, and forestry. The hailstorm mentioned above caused great damage to this work. There was also a heavy loss to nursery stock and young forest seedlings through winterkilling following several days of bright warm weather in midwinter. A 5-acre plantation of young conifers was practically ruined in this way, perhaps less than 2 per cent of the trees surviving. As soon as possible, plant breeding with plums and strawberries will be begun, the new greenhouses offering facilities not hitherto available.

Work in farm engineering has been begun, and investigations on the draft of plows, sources for fence posts, and drainage are being carried on. Considerable progress has been made in cereal breeding, and about 1,000 farmers throughout the State have received seed for cooperative trials. Little was done the past year on soil work. The rotation experiments have been continued and modified so as to include a leguminous crop and other forage plants, and the results contrasted with continuous grain growing. Times and rates of seeding for all the important crops are being studied.

In animal husbandry, breeding experiments with sheep and hogs are being conducted. The feeding value of barley and low-grade wheat as compared with corn for hogs is being determined, and efforts are being made to determine the cost of milk production with various commonly available feeding stuffs. The poultry work has been extended and a large number of experiments are in progress, including breeding experiments, housing, egg production, effect of exercise and age as affecting fertility of eggs.

The assistant director has general oversight of the substations, four of which are supported by the State. At Edgerly and Dickinson general investigations are in progress on crops, soils, methods of tillage, rotation experiments and introduction and breeding experiments with various crops. At Williston considerable delay was caused by a partial failure of the water supply, but some data were obtained on the relative value of hillside, furrow, and flooding methods of irrigation when applied to various crops.

The chemical department made a large number of analyses for other departments of the station, analyzed food and feeding stuffs, and carried on paint investigations and water analysis. Considerable attention is being paid to a study of methods of soil and cereal analysis, and some modifications have been discovered.

An outbreak of hog cholera during the year gave the veterinarian an opportunity to test, prepare, and distribute the serum discovered by the Bureau of Animal Industry of this Department.

The station, through funds supplied by the State, is carrying on a very considerable amount of demonstration work. Twelve leased farms are now maintained in different parts of the State. They usually consist of 20 acres and are operated by the owner under direction of a superintendent. The owner gets the crop and $100 per annum. The fund available for this purpose is $7,500, and it is thought that six or eight more farms will be added next season. The work carried on is diversification farming, rotation experiments, and moisture and temperature observations in connection with each crop grown.

Cooperative work has been arranged with the Bureau of Plant Industry of this Department for carrying on a series of investigations to determine the influence of climatic conditions upon the production of wheat and its milling properties, the influence of frosting, bin burning, heating, and a study of the several varieties of wheats, also the same variety grown in different parts of the United States, and a further study to determine the difference in the chemical properties between good milling wheats and bread-making wheats from those which are found to be of inferior quality for this purpose.

The following publications have been received from this station during the past year: Bulletins 76, Experiments with Indian corn, forage crops, leguminous crops; 77, Bovine tuberculosis; 78, Poultry experiments, care and management of the flock; 79, The distribution of pedigree seed; and 80, Weeds and methods of eradication, weed control by means of chemical sprays; Special Bulletins 5, Agricultural laws—1, Feeding-stuffs law—2, Formaldehyde law—3, Paris green law—4, Fertilizer law; and 6, Food and drug laws—1, Pure-food law (amended and reenacted)—2, Pure-drug law (amended and reenacted)—3, Paint law—4, Rulings and discussions.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	8,000.00
Balance from previous year	6,092.96
Individuals	500.00
Live stock	1,501.65
Farm products	1,734.45
Miscellaneous, including balance from previous year	2,295.18
Total	44,124.24

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The North Dakota Station is extending and broadening its usefulness and is winning the confidence and support of those whom it is trying to help.

OHIO.

Ohio Agricultural Experiment Station, *Wooster.*

C. E. Thorne, M. S. A., *Director.*

There have been few changes in the personnel and organization of the Ohio Station during the past year and the work of the station has been along the same general lines as in former years.

Work under the Adams Act has been confined to the three lines stated in the report for 1907. The plant-breeding investigation has been with wheat, corn, oats, and alfalfa, and has involved the study of a large number of individual plants. In the study of the relation between the lime content of soils and the crops grown, soils at the station and from other places in the State are being used. The laboratory of animal nutrition has been well equipped and experiments on the metabolism of phosphorus have been undertaken with pigs. Along with this the chemist is making a study of the relation of the phosphorus content of soils to the crops and ultimately to the animals grown on them.

In horticulture the greenhouse work included breeding of cucumbers and tomatoes from individual plants. Outside there has been a continuation of studies on the self-pollination of fruits and experiments in the culture and mulching of orchards, especially apples. The forestry work is growing in extent. Considerable plantations have been made at the station, especially of catalpas and locusts. Over 500 persons are cooperating with the station in this work, some in every county. A large amount of detailed data on the forest conditions in the State has been gathered through circulars of inquiry.

The original investigation of the botanical department is a study of grain anthracnoses, in which it is thought that a new distinction of such diseases has been made.

Studies have been made with a new form of spraying mixture including Bordeaux and iron sulphate as a "sticker." This used on potatoes and apples has given results indicating the greater effect of such a mixture with less expense. Some breeding experiments with corn and oats at the station have been continued, but will be turned over to the agronomist. The plant-disease survey of the State is being continued in cooperation with the Bureau of Plant Industry of this Department, and breeding experiments with tobacco at Germantown are being made in cooperation with the same Bureau. Seed and wheat examinations are increasing in number, about 1,000 having been made the past year. It has also greatly increased the correspondence. Plans are being made to have the botanical laboratory in the proposed new wing of the station building.

The entomologist is continuing the work on insects affecting Ohio shade trees and on spraying for the codling moth. Reports on both

of these subjects have been published. A bulletin on leaf spot caused by the catalpa sphinx is being prepared. The outbreak of the wheat jointworm, which caused much damage in various parts of the State, has been investigated. Similar work on the grape-berry worm has been carried on. Bark borers, troublesome in northern Ohio, are being studied in cooperation with the Bureau of Entomology. Some work has been done on the woolly louse of the apple, in cooperation with the State department at Columbus, and this work will be increased next season. Among other studies is one of the raspberry beetle. This department of the station receives about 3,000 letters annually.

Aside from the breeding work, the lines of experimental work in agronomy at Wooster are about as heretofore. At the three test farms in different parts of the State the work is principally the testing of improved varieties, but some breeding work is being done there.

Selected seed from six varieties of wheat, improved as result of station work, were grown in 100-acre fields and compared with miscellaneous seed from these varieties, with the result that the crops on selected heads gave an excess yield of 4½ bushels per acre.

Outside of the Adams fund work the chemist has chiefly worked for other departments, especially in connection with the crop-breeding experiments in agronomy.

In animal husbandry, experiments with beef cattle have been continued. As a result of the experiments in the use of silage it has been shown that with good management it is profitable to use silage in feeding cattle for beef. It is, however, necessary that hogs should follow the steers and that all manure should be carefully utilized.

Hogs fed on tankage with corn and pasture produced the largest gains. In hog-feeding experiments, individual litters and also the individuals in litters are being considered with reference to both breeding and feeding. Work horses fed on corn, as compared with oats, showed equally good results at less expense. Work with sheep is being enlarged, and studies are being made on individuals with reference to reproduction, milk, meat, and wool. Dairy animals are being fed with reference to economical production of milk, soy beans having been tried as a ration with good results.

Cooperative experiments have been greatly extended in number and in scope. Plans for the work are systematically made and followed up by personal visitations. An effort is being made to create centers of improvement in every county and ultimately in every township. Special efforts are being made to have cooperation with the reform schools and other State institutions in feeding and crop experiments and forestry, in the hope to extend this work. In Ohio there are 20 such institutions with a population of 25,000 persons.

An extensive piece of work is being carried on in farm management in cooperation with the Bureau of Plant Industry of this Department. Thirty-six farms in different parts of the State are reporting their daily hours and kinds of work, expenses, and income. A large amount of data has already accumulated, and this is being worked up by several men under the direction of Professor Goddard.

Exhibits at fairs are being extended. The station was especially successful with its exhibit at the State fair this year.

The three test farms in different parts of the State are being maintained as heretofore. The lease of the farm at Strongville is about to expire and the legislature will be asked to purchase the farm. The work has been going on for fourteen years.

Nine bulletins and nine circulars have been received from this station during the past year, as follows: Bulletin 182, The maintenance of fertility—field experiments with cereal crops and potatoes—summary of results for thirteen years, 1894–1906, inclusive; 183, Maintenance of fertility—the production, reinforcement, and value of manure; 186, Strawberries—the newer varieties; 187, Fattening range lambs; 188, Forest conditions in Ohio; 189, Forestry suggestions; 190, Evergreens—their uses and culture; 191, Spraying apples; and 192, Fall and early winter injuries to orchard trees and shrubbery by freezing. Circulars 71, The selection of seed corn; 72, Celery root rot; 73, Tankage for hogs in cattle feed lots; 74, Seed corn for the season of 1908; 75, Cooperative forestry work for 1908; 76, Cooperative corn work for 1908; 78, The soy bean—uses, varieties, culture, and harvesting; 79, How to determine the fertilizer requirements of Ohio soils; and 80, Cooperative alfalfa work in 1908.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	84,000.00
Balance from previous year	28,769.88
Farm products, including balance from previous year	11,109.03
Miscellaneous	8,746.25
Total	156,625.16

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The affairs of this station are now in a very prosperous condition; the work is being industriously and systematically pursued. Scientific work is growing in extent and importance, and at the same time unusually active efforts are being made to bring the practical results of the station work home to farmers in every part of the State.

OKLAHOMA.

Oklahoma Agricultural Experiment Station, ***Stillwater.***

Department of Oklahoma Agricultural and Mechanical College.

B. C. Pittuck, *Acting Director.*

The work of the Oklahoma Station was along the same general lines as in the previous year, and satisfactory progress was made on several original research investigations of considerable importance.

The Adams fund projects were continued. The work in animal breeding included the study of the vitality of semen and conditions influencing it; so far this work has dealt largely with the physiological side of the question; it is expected that results of this work will be published early in 1909. The breeding work with corn for the purpose of securing drought-resistant strains was extended to plants belonging to the sorghum group, with the same object.

A new project was begun in the latter part of the fiscal year including the investigation of the San José scale disease discovered in Oklahoma, and the study of a chinch-bug disease which is present in all parts of the State.

Aside from Adams fund work in the department of horticulture and botany, the principal investigations and experiments carried on during the year were along the line of variety tests of fruits and plants, methods of forestry planting, potato breeding, orchard spraying for the protection of trees and fruit against the attacks of codling moth, scab, bitter rot, skin blotch, fly speck, and other diseases, and work of orchard cultivation. The work of spraying demonstrated that from 50 to 90 per cent of the crop of apples may be protected by spraying.

The veterinarian and bacteriologist continued the study of Texas fever and published the results of several years' work. The relation of certain bacteria to the flavor of butter was studied.

The entomologist carried on field tests and life-history work with the bollworm, the plum curculio, and the codling moth. It was found that 90 per cent of the apricot crop can be saved from the ravages of the plum curculio by timely sprayings of arsenate of lead, and that the bollworm can be successfully checkmated in the cotton fields by the use of June corn, planted the first of June in the cotton field, 200 or 300 feet apart.

The agronomist continued the study of the staple field crops of the State, including cotton, alfalfa, cowpeas, soy beans, wheat, and corn.

The practical and scientific features of the field experiments with several of these crops were published.

The department of animal husbandry completed feeding experiments to determine the efficiency of different rations for fattening hogs and sheep and published the results. A digestion experiment with Bermuda hay was also completed.

Besides routine analyses and work in cooperation with other departments of the station, the chemist made quite an extensive study of the composition of Bermuda grass.

Under the new State constitution the board of agriculture is made the board of regents for the college and station. The president of the college retired at the end of the collegiate year and was succeeded by J. H. Connell, director of the Texas Station from 1895 to 1902. In accordance with the requirements of an act of the legislature the college created a chair of agriculture for schools, and E. E. Balcomb, formerly teacher of agriculture at the Southwestern State Normal School at Weatherford, Okla., was chosen for the position.

The publications received from this station during the year were as follows: Bulletins 73, Hardy trees, shrubs, and vines; 74, Cowpeas and soy beans; 75, A study of the bacterial content of cream; 76, Orchard spraying; 77, Cotton culture; 78, Sheep feeding; 79, San José scale in Oklahoma; and 80, Rations for fattening hogs. Circulars 6, The value of gaseous disinfectants; 7, The value of cotton improvement; 8, The spring grain aphis; 9, Hessian fly; and 10, Corn growing in Oklahoma; numerous press bulletins; and the Annual Report for 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	718.80
Miscellaneous, including balance from previous year	2,846.02
Total	27,564.82

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

Since the close of the fiscal year the director has resigned and has been succeeded by J. A. Craig. The animal husbandman has resigned, and W. A. Linklater, of the Washington College and Station, has been appointed to fill the vacancy. Cornelius Beatty has succeeded the former chemist, and R. O. Baird has been appointed assistant chemist. The department of botany has been transferred, in both the college and station, from the department of entomology to that of horticulture.

OREGON.

Oregon Experiment Station, *Corvallis*.

Department of Oregon State Agricultural College.

JAMES WITHYCOMBE, M. Agr., *Director*.

The Oregon College and Station are in a very prosperous and flourishing condition. The legislature has been generous in providing

funds for new buildings, and the old main building is being remodeled, a new agronomy building is nearing completion, and a new stock and dairy barn is completed and occupied. The institution has had $65,000 per annum for building purposes the past two years and $50,000 for maintenance. It is expected that the appropriations for building will be continued for the next two years at least. In the remodeled building ample quarters have been provided for a library and reading rooms, and a trained librarian and assistant have been secured and are engaged in rearranging and classifying the library.

One of the Adams fund projects—a study of the digestibility of steamed corn and vetch silage—has been concluded and the results prepared for publication. The other projects enumerated in the report for 1907 have been actively carried on. In the department of entomology considerable progress is reported on the preparation of the lime-sulphur spray and its use as an insecticide and fungicide, and the investigations on apple-tree anthracnose and cherry gummosis are progressing satisfactorily. Considerable progress has been made on the conditions affecting apple pollination, and the relation of self-fertility and sterility, times for pollination, and transportation of pollen are being studied. Data are being collected regarding the irrigation of orchards. The soil-leaching studies have already shown some interesting results, among them the retention of the surface lime in the subsoils and the loss of potash and phosphoric acid. In the investigation on hops the necessity of drying at lower temperatures is apparent if a superior quality is desired. Comparisons are being made between the best grades of Oregon and Bavarian hops, and the possibilities of hop breeding are shown by results already obtained. The poultry department is being equipped for the project on the incubation of hens' eggs.

The bacteriologist is continuing his studies on butter and cheese. He is testing the addition of cultures to butter just as it reaches the granular stage in the process of churning, and is meeting with marked success. He is also studying the effect of the temperature of pasteurizing cream on the character of butter.

The horticulturist is continuing variety tests in the old and new orchards, studying cover crops for commercial orchards, testing small fruits for Oregon, studying disease resistance in potatoes in cooperation with the Bureau of Plant Industry of this Department, and conducting fertilizer experiments. Many of these investigations are carried on in cooperation with fruit growers and farmers in different parts of the State.

The entomologist has devoted much time to comparing the efficiency of lime-sulphur compounds with Bordeaux mixture for controlling apple scab and other diseases, and the lime-sulphur mixture seems very promising as a fungicide. This was also tested on peaches

with success. The entomologist found that lime-sulphur compound sprayed on elm trees in spring as the buds were beginning to open was a specific in the prevention of leaf galls caused by elm-leaf aphis.

The chemist has had an unusual amount of routine analytical work, and under a new law the chemical department will make fertilizer analyses, the fees for which will be turned over to the department. The chemist has spent much time on the analysis of spraying materials and in the preparation for publication of the results of the digestion experiments with cooked corn and silage.

The poultry department is just being organized, and a good plant is being provided; breeding and feeding experiments have been begun. (Pl. VII.)

The dairy department is continuing the test of the milking machine, and will terminate the test December 31, 1908. The relation of speed, temperature of milk, and fat content of milk to the quantity of cream produced by hand separators is also being studied, and tests are being made of the individuals of the dairy herd.

The department of agronomy is studying long and short rotations, relative value of different forage and grazing plants, and of early disk plowing and late moldboard plowing, breeding experiments with clover for the so-called "white lands," wheat, vetches, maize, and kale.

In animal husbandry the work has been limited by lack of funds, and has been confined to feeding experiments with pigs to determine the cost of pork production when fed on alfalfa, grain, skim milk, and ground wheat and barley in varying proportions.

The irrigation experiments in cooperation with this Office are progressing favorably, and approximately 5 acres are now in the experiment, the crops being clover, potatoes, corn, and kale. The second crop of clover when cut yielded 2,040 pounds on unirrigated plat and 7,530 on irrigated area.

During the year a shipment of peppermint roots was received from the Michigan Station, sent by request, for testing on beaver-dam soils. Through the cooperation of a farmer of Washington County they were planted and will be tested for oil in due time.

Two bulletins have been received from this station during the year, as follows: Bulletins 95, Disease of turkeys; and 96, The poultry industry in Oregon.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Farm products	2,584.48
Balance from previous year	25.47
Total	26,609.95

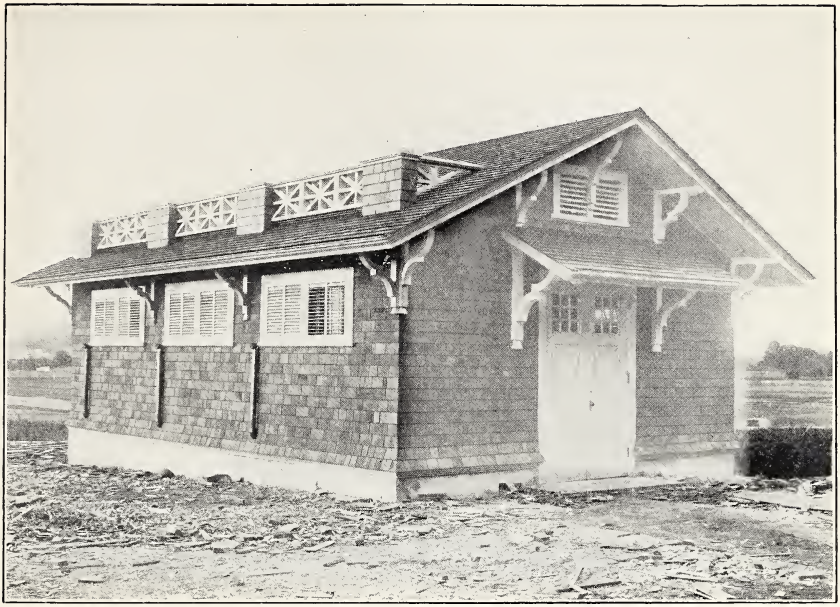

FIG. 1.—INCUBATOR HOUSE, OREGON STATION.

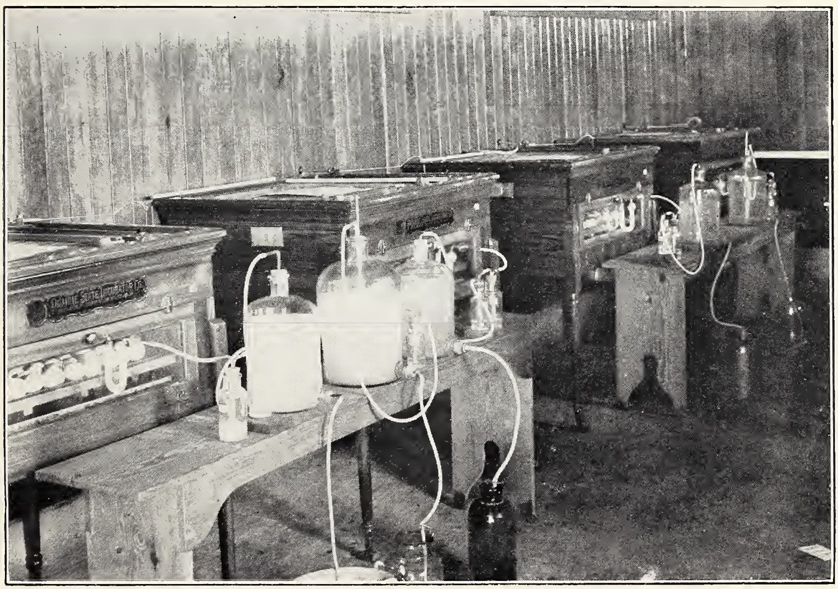

FIG. 2.—SECTION OF INTERIOR OF INCUBATOR HOUSE, OREGON STATION, SHOWING METHOD OF MAKING DETERMINATIONS OF CARBON DIOXID IN INCUBATORS.

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Oregon Station is doing much to make the results of its work accessible to the farmers of the State and is meeting with success in such efforts.

PENNSYLVANIA.

The Pennsylvania State College Agricultural Experiment Station, *State College.*

T. F. Hunt, D. Agr., D. Sc., *Director.*

The Pennsylvania Station has been thoroughly organized on the departmental system during the past year. The general plan is to organize the departments so that certain persons may devote their time wholly or chiefly to instruction, while others may give their time wholly or chiefly to investigation. Records of work of each department are made in duplicate and a copy filed in the director's office. The project system is followed for all work.

Under the Adams Act investigations in the three lines stated in the report for 1907 have been systematically prosecuted. The metabolism experiments with steers have been conducted with the respiration calorimeter through the institute of animal nutrition in cooperation with the Bureau of Animal Industry. Animals from the Missouri Station have been used during the past year. Thirteen experiments were made and a large amount of data obtained. The horticultural investigations to determine causes which affect the yield and quality of apples have been planned to include studies in orchards at the station and in ten other localities where orchards have been leased for ten years. Experiments with cultural methods and fertilizers are being made, and the effect of the different treatments on the soil will be studied. The investigations in soil fertility are being conducted in connection with the series of fertilizer plats at the station which have been under experiment during the past twenty-five years. Both chemical and physical studies are included in this project.

In horticulture the principal experimental work in addition to that under the Adams Act will be with asparagus, early and late cabbage, and tomatoes. With asparagus the following things will be considered: Size and age of crowns, relative value of spring and summer fertilizing, relation of size of seed to vigor of plants, yield, disease resistance, best methods of propagation, varieties, etc. With cabbages the following points will be considered: Seed from different sources, age and size of seed, large versus small plants in transplanting, seed selection, fall-grown versus spring-grown plants, and fertilizing.

With tomatoes, studies will be made on the same plan as for cabbages; also single-stem training, varieties for canning, fertilizers, culture previous to final transplanting, etc.

The department of agronomy is making studies of varieties of wheat, oats, and potatoes with a view to their improvement, corn breeding, field-selected versus crib seed corn, seed of individual timothy plants brought from Cornell, experiments with fertilizers and lime for alfalfa, and special lime experiments in which the form, fineness, and quantity of lime will be considered as related to acidity and humus content of soil. Hessian-fly experiments will be carried on in cooperation with the Bureau of Entomology.

Much chemical work has been done for different departments of the station. The tobacco experiments, including seed selection and cooperative experiments with fertilizers have been continued.

The control work continues to be large, much additional work having been caused by the food control.

In animal husbandry, experiments have been made on fertility of eggs of fowls kept under the same conditions. Experiments on the effect of shelter on fattening steers have been finished. A feeding experiment was made with 48 cattle in four lots of 12 each, in which a large corn and small silage ration was compared with a large silage and small corn ration. The results were not far apart when everything was taken into account.

The department of dairy husbandry has made feeding experiments with concentrated and bulky rations for dairy cows. Tests of milking machines have been made, and studies are being made of Pennsylvania butter, especially commerical tests for moisture in butter, and the Taylor absorption method for making butter.

A bacteriological study of blood of poultry has been begun, and it is planned to develop this with reference to establishing a normal standard of the blood of poultry as a guide to studies of diseases.

In botany plans are being made for studies of clover diseases and cankers of apples. A laboratory is being fitted up in the upper story of the old station building. It is also hoped to cooperate with the Bureau of Plant Industry of this Department in a plant-disease survey of the State.

Studies are being made of forestry nurseries, tree breeding and introduction, wood-lot management, tree-seed collection and storage, and treatment of fence posts. A small tree nursery has been established back of the forestry building.

The past year has been a period of reorganization of the college as well as the station. The faculty has been largely increased and courses of study elaborated. There is much greater interest in the work and the number of students has greatly increased. Attention

is being given to extension work and to the teaching of agriculture in the lower schools. The college undertook to teach agriculture in two of the teachers' institutes held in the summer, the plan being to follow the secondary course in agronomy as published in Circular 77 of this Office.

The new agricultural building is already too small, and plans are being made for its enlargement.

The following publications have been received from this station during the year: Bulletins 82, Winter-wheat varieties; 83, Methods of steer feeding; 84, Feed as a source of energy; 85, Test of a mechanical cow milker; and 86, Miscible oils, how to make them; and the Annual Report for 1906.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$14,999.74
Balance from previous year, Hatch Act	.26
United States appropriation, Adams Act	9,000.00
State appropriation	4,000.00
Fees	15,720.40
Farm products	7,794.21
Miscellaneous	603.78
Balance from previous year	3,779.71
Total	55,898.10

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

In general, the new administration has already infused new life and vigor into the work of the Pennsylvania Station. The new work inaugurated is along lines which may yield results of great usefulness to the agriculture of the State. The broadening of the experimental work of the station will seriously tax its resources and necessitate greater liberality on the part of the State in its maintenance. The increased activity of the college in extension work will enable the station to bring its work more effectively to the attention of the farmers of the State.

The Pennsylvania State College, Institute of Animal Nutrition, *State College.*

H. P. Armsby, Ph. D., LL. D., *Director.*

The Institute of Animal Nutrition, aided as in previous years by the Bureau of Animal Industry of this Department, was occupied during the year 1907–8 with investigations, in cooperation with the Missouri Experiment Station, upon the utilization of feed in the growth of cattle.

These investigations are upon three uniform lots of cattle which have been receiving since birth, respectively—

Group I. Full feed, with the object of producing baby beef.

Group II. A ration sufficient to secure normal growth with no considerable fattening.

Group III. A ration deficient in both protein and total food.

The Missouri Station is determining the amount and chemical composition of the increase in live weight and its relation to the feed consumed. The work undertaken by the institute of animal nutrition includes determinations of—

A. The maintenance requirement, expressed in terms of net available energy, of a representative animal from each group at different ages.
   (1) On hay alone.
   (2) On a mixed ration of the same materials and in the same proportions as that fed the remaining animals of the lot at the Missouri Station.

B. The net available energy and the utilizable energy of the feeds used, to be determined by experiments upon a representative animal of each group at different ages.

C. The influence of the age and condition of the animal on the above factors, as shown by a comparison of the results in successive years and on different animals.

In pursuance of the plan outlined above, 13 runs with the respiration calorimeter were made during the year, the results of which, however, have not yet been fully computed. It is expected to continue the work during the present year.

About December 1, 1907, the work of the institute was transferred to its permanent quarters in the new agricultural building. These consist, in addition to the respiration calorimeter building, of two commodious and well-equipped chemical laboratories with storeroom, balance room, and room for the drying, grinding, and preparation of samples; a special room with double masonry walls for work with the bomb calorimeter; an office and library; a stenographer's room; and the director's private office. These rooms have a direct connection with the respiration calorimeter building. The total floor space, inclusive of the latter building, is about 5,000 square feet.

PORTO RICO.

Porto Rico Agricultural Experiment Station, *Mayaguez.*

Under the supervision of A. C. True, Director, Office of Experiment Stations, United States Department of Agriculture.

D. W. May, M. Agr., *Special Agent in Charge.*

A number of additions were made to the station staff during 1908. Dr. Oscar Loew, formerly of the United States Department of Agri-

culture and later of the College of Agriculture of the Imperial University of Tokyo, was secured as physiologist; P. L. Gile, a graduate of Harvard University, as chemist; and E. G. Ritzman was transferred from the Bureau of Animal Industry of the United States Department of Agriculture as assistant animal husbandman. Doctor Loew remained at the station for a few months only, when he resigned to take up some private work in Germany. During the year a much-needed chemical laboratory was installed and furnished with a gas machine, water, and a working equipment. During the time Doctor Loew was connected with the station as physiologist he carried on some important studies on the fermentation of coffee, cacao, and tobacco.

The chemical work has thus far been mainly a study of the soils and their fertilizer requirements. Investigations were made of some alkali soils in the arid portion of the island and acid soils on the north side, and gypsum was successfully employed to correct the alkalinity and freshly burned lime to modify the acidity of the soils.

The horticulturist is continuing the lines of work described in previous reports, paying especial attention to methods of propagation and cultivation of pineapples, citrus fruits, mangoes, bananas, etc. Breeding and selection experiments with many of the more important tropical fruits are in progress. The station has large collections of improved varieties of tropical and subtropical fruits and is distributing the plants as rapidly as possible. Experiments in shipping pineapples and citrus fruits are in progress.

The entomologist has made an especial study of means of combating injurious insects, and considerable time was spent during the past year in demonstration work with planters, showing them how to prepare and apply fungicides and insecticides. Some work with bees has also been begun, colonies of Italian bees having been introduced from the States for this purpose. In pathology the diseases of citrus fruits, pineapples, coffee, and sugar cane have been given some attention.

The station is carrying on some very successful experiments in growing seedling sugar canes. A number of promising varieties have already been produced, and after further testing at the station they will be disseminated throughout the island. Seedling pineapples are also being produced. Particular attention is being given to the problem of reforesting the barren hills of the island. Experiments at the station have shown the adaptability of certain species of Eucalyptus for this purpose. The broad-leaved Honduras mahogany has also succeeded well, and it will undoubtedly be a desirable addition to the forests of the island. In the lower lands rubber, cacao, coconut, and other trees have been successfully planted.

In animal husbandry the foundation of a dairy herd has been established and a dairy barn is in course of erection. A considerable

number of pigs and poultry have been bred and sold to planters, but the supply can not equal the demand. No particular difficulties have thus far been met with in raising any of the better strains of farm animals.

At the coffee substation there are now 35 acres under experiments. These experiments include investigations on the improvement of the native coffee through pruning, fertilizing, cultivation, etc., the introduction of the best varieties from different parts of the world, selection, breeding, etc. Some of the introduced varieties are now in bearing and the seeds are being distributed among planters of the island to induce them to grow coffees better suited to the trade. The demand for seed far exceeds the present resources of the station.

Considerable cooperative work is carried on between the station and planters, the United States Department of Agriculture, insular government, etc., all of it being with a view to improving the condition of the agriculturists of the island.

The publications for 1908 consisted of the Annual Report and Circular 7, Control of the brown ant and the mealy bug in pineapple plantations.

The revenues of the station for the fiscal year ended June 30, 1908, were as follows:

United States appropriation	$24,000.00
Farm products	3,546.15
Total	27,546.15

The insular legislature at its last session appropriated $20,000 for the erection of a building for the exclusive use of the station. Plans have been drawn for a concrete structure that will amply provide for the present needs of the station for office and laboratory quarters, and this appropriation may be taken as an indication that the people of Porto Rico appreciate the work of the station in attempting to improve the agricultural practices of the island.

RHODE ISLAND.

Rhode Island Agricultural Experiment Station, *Kingston.*

Department of Rhode Island College of Agriculture and Mechanic Arts.

H. J. Wheeler, Ph. D., *Director.*

The work of the year at the Rhode Island Station was continued in the main along lines followed in previous years, but with a number of changes in personnel and organization. At the beginning of the year B. L. Hartwell was made chemist, with direct control of all of the chemical work of the station. The horticulturist severed his connection with the college and station to go into private business June 30, 1907. His place as horticulturist, particularly in green-

house work, was filled by G. E. Adams, formerly associate agronomist of the station. On September 1, 1907, L. J. Cole, Ph. D., a graduate of Harvard University, was made chief of the new division of animal breeding and pathology, which was organized to continue the work with poultry formerly conducted by Dr. Cooper Curtice. About the close of the fiscal year Doctor Cole accepted the position of instructor in zoology in Yale University, but is expected to continue supervisory oversight of the work at the station, which will be in direct charge of P. B. Hadley, Ph. D., of Brown University.

The most striking evidences of progress in the work of the station were the more definite development of several fundamental problems of plant physiology growing out of the carefully planned and conducted field experiments which have been carried on by the station for a number of years; the development of experiments in greenhouse floriculture; and the more systematic organization of the investigations with poultry. As a result there have been undertaken a number of most promising projects, resting in most cases upon large accumulations of valuable data secured in previous investigations, records have been systematized and completed, and equipment perfected. It would seem as if the station were in a better position than ever before to prosecute successfully the important scientific problems which its previous work has logically led up to and furnished a basis for.

Satisfactory progress in seven Adams fund projects is recorded. Two of these were new projects, viz, the influence of physical soil factors and of various chemicals upon the growth of vegetables and flowering plants under glass, and physiological effect of sodium, iron, and other compounds in the soil. Progress reports on certain features of several of the projects were published during the year; for example, on blackhead of turkeys,[a] which was investigated in cooperation with the Bureau of Animal Industry of this Department; and the relation of the chemical composition of crops to phosphorus and potassium deficiencies in the soil.

In addition to and along with the projects referred to above, the systematic and extensive field experiments which the station has carried on for several years were continued. These included several series of rotations with various crops commonly grown in Rhode Island; comparative tests of phosphates of different kinds, including bone, basic slag, acid phosphate, Peruvian guano, Redonda phosphate, and floats; experiments with lime and other fertilizing materials on grass and other crops; trials of alfalfa; experiments with grasses and other forage plants, including study of methods of preparation of land for grass, effect of continuous culture, best mixtures to use, fertilizing, etc.; experiments on soda as a substitute for potash

[a] Rhode Island Sta. Bul. 124.

in plant growth; experiments to test the effect of the growth of certain plants upon the plants which follow on the same land; tests of varieties and selection of flint corn adapted to Rhode Island conditions in cooperation with the Bureau of Plant Industry of this Department; experiments on the exhaustion and renovation of land by continuous cultivation without manure; effect of lime on a great variety of perennial flowering plants; experiments to learn the limit of profit in nitrogen, phosphoric acid, and potash manuring; tests of seedling strawberries; propagation experiments with the swamp blueberry; tests of blackberry and raspberry crosses; selection experiments with sweet corn; and breeding disease-resistant potatoes and frost-resistant beans.

Pot experiments are being made to test the availability of the potash in feldspar and of the nitrogen in various low-grade nitrogenous fertilizers; to determine the nitrogen balance with leguminous plants; and to study the effect of different amounts of water on the efficiency of fertilizers.

Some experiments in pigeon breeding have been begun, mainly to study inheritance of characters. Some study has also been given to the mating of bees and to an organism causing ropy milk. Feeding experiments with poultry were also carried on.

The chemical department of the station continued to have charge of the State fertilizer and feeding stuff inspection, and in addition made a number of analyses of miscellaneous materials.

The publications of the station received during the year were as follows: Bulletins 118, Continued test of nine phosphates with different plants; 119, Commercial feeding stuffs; 120, Soil tests in paraffined wire baskets compared with tests on farms; 121, A study of Rhode Island soil requirements by means of field tests; 122, Analyses of commercial fertilizers; 123, The rearing and management of turkeys, with special reference to the blackhead disease; 124, Further experiments in connection with the blackhead disease in turkeys; and 125, Commercial fertilizers; and the Annual Report for 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Miscellaneous	1,338.46
Balance from previous year	3,947.94
Total	29,286.40

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Rhode Island Station continues to maintain a high standard of scientific work, which is at the same time furnishing practical results of great value to the agriculture of the State.

SOUTH CAROLINA.

South Carolina Agricultural Experiment Station, *Clemson College.*

Department of Clemson Agricultural College.

J. N. Harper, B. S., M. Agr., *Director.*

The board of control of this station decided upon a complete and clearly defined separation of the station from the agricultural department of the college, which took effect July 1, 1908. Under the new organization the station men will have no college duties, and distinct farm and laboratory equipment will be provided for the station. The station has organized departments of agriculture, horticulture, botany, and bacteriology (plant pathology), animal husbandry, entomology and zoology, and chemistry. About 300 acres of the college farm was definitely set apart for station purposes. Seed rooms and a workman's cottage were built on the station farm during the year.

A coast-land substation, to investigate particularly drainage questions and the production of forage plants, was organized near Summerville on 300 acres of low land donated by the Southern Railway. The work is under the direct supervision of the director of the station, but is maintained by State funds. A committee of the board of trustees, of which the director of the station is a member, has charge of the preliminary arrangements. This substation takes the place of the smaller substation, which has been maintained for several years in the same locality.

Some work was done during the year on all except one of the Adams fund projects filed with the Office. Certain phases of the investigations on rice blast were completed during the year, and a preliminary report on the hook-worm disease of cattle (uncinariasis) was published, the investigations on the stomach-worm project having yielded important facts regarding soil infestation, hibernation, and transmission of hook worms and their prevalence in association with the stomach worms. A new project, a study of anthracnose of cotton, was undertaken.

In addition to Adams fund work the agriculturist carried on experiments in individual plant and boll breeding of cotton; variety and fertilizer tests of cotton; tests of saw-ginned and roller-ginned cotton fiber; variety and culture tests of alfalfa, cowpeas, vetches, and other forage plants, the latter in cooperation with the Bureau of Plant Industry of this Department; cultural and fertilizer tests with corn, including a continuation of tests of the Williamson method; and a continuation of studies of effect of environment on sweet corn in cooperation with the Bureau of Chemistry of this Department.

The work in the horticultural department included pruning and training of forced tomatoes; variety tests; crossing and hybridization of grapes; selection of strawberries and asparagus; trellising of

peaches; variety tests of apples, cherries, pears, peaches, and potatoes; crossing and pruning of Rotundifolia grapes; experiments with seedling apples and pecans; fall planting of onions; second-crop potatoes; and spraying peaches.

The entomologist gave attention to observations on the plum curculio, woolly aphis, peach-tree borer, and the rice louse, and to cereal and forage crop insects in cooperation with the Bureau of Entomology of this Department. Some work was done on the entomological collections.

The plant pathologist did some work on sweet-potato diseases, especially rot, and cooperated with the Bureau of Plant Industry in a plant-disease survey of the State and with the Forest Service in the preservation of posts with creosote. The geologist carried on studies of soil erosion.

In the department of animal husbandry, experiments in feeding rice meal to hogs were carried on.

The veterinarian gave particular attention to tick eradication in cooperation with the Bureau of Animal Industry of this Department and reports encouraging progress in several northwestern counties of the State, three counties having been provisionally released from quarantine.

In the chemical department some very interesting experiments in the manufacture of starch from sweet potatoes were completed, indicating valuable possibilities in this line of utilization of the sweet potato. Fertilizer inspection and some miscellaneous analytical work were also done.

The following publications of the station were received by the Office during the year: Bulletins 126, Analyses of commercial fertilizers; 131, Cotton-seed meal and corn silage as a ration for dairy cows; 132, Rotundifolia grapes; 133, Report of coast-land experiments; 134, The San José scale; 135, The Williamson plan in 1907; and 136, The manufacture of starch from sweet potatoes.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Farm products	1,809.75
Miscellaneous	1,628.01
Total	27,437.76

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

It is believed that the sharp differentiation of college and station work which has been made at the South Carolina Station will enable the station to more vigorously prosecute the many important lines of inquiry which it has under way.

SOUTH DAKOTA.

South Dakota Agricultural Experiment Station, *Brookings.*

South Dakota State College of Agriculture and Mechanic Arts.

J. W. Wilson, M. S. A., *Director.*

The work at the South Dakota Station during the past year has been along the same general lines as previously reported. With the exception of the appointment of Mr. Clifford Willis, as head of the agronomy department, the heads of the departments were the same as for the previous year.

Two new projects were approved for investigation under the Adams Act—the influence of rotations on soil fertility, and the effect of alkali waters in dairying. The other projects were continued, as previously reported. The station is devoting much attention to breeding hardy economic plants for the Northwest, and this forms an important part of the Adams fund work. More than 70 acres are devoted to this work, and many thousand seedlings are now under observation. The study of the digestibility of local grains and fodders has been in progress with sheep for three years, and it is proposed to take up similar investigations with horses to determine standards for rational feeding. Considerable additions were made to the laboratory equipment of the veterinary and dairy departments, and prominence will be given to their projects in the future.

In the dairy department studies are being made of the physical and chemical characteristics of South Dakota butter, the relation of acidity to the flavor of butter, and the effect of different factors, such as pasteurizing, washing, and freshness of cream, on acidity are being investigated. Data are being collected on the amount of feed consumed by each cow and a record made of the milk yield and butter fat produced, the object being to determine the cost of production.

The agronomist began work at the station in February, 1908; he has begun experiments to secure pure strains of the different crops experimented with, and is doing some variety testing. In an experiment with wheat on the fourth crop from prairie sod, the addition of nitrogen in fertilizers gave a gain of 30 per cent, phosphoric acid about equaled the check, and potash alone diminished the crop by 12 per cent.

The chemist has continued breeding and selection work with sugar beets and reported securing one mother beet that gave a yield of 24 per cent sugar. The seed from this beet has been saved for planting next year. A large number of miscellaneous analyses were made for other departments of the station.

In animal industry, experiments with sheep breeding and feeding are continued. Grade ewes are crossed with rams representing six

different breeds, and account is kept of the wool clip, amount of feed, and market price of the lambs. The third crop of lambs is now under study. Experiments are continued in breeding a Yorkshire-Poland-China cross-bred variety of pigs. Feeding experiments with lambs and steers are being conducted to test the value of rape for lambs, age on feeding value of steers, and the relative value of sorghum, alfalfa hay, and prairie hay for lambs. All lots received the same grain ration, and the superiority of alfalfa hay was clearly shown.

Some feeding experiments with stock foods are being conducted in cooperation with the chemist.

The veterinarian is carrying on cooperative experiments with the Bureau of Animal Industry on cattle dipping for mange prevention and dipping sheep for scab.

The entomologist has, by law, considerable inspection work to do, and has given considerable time to the identification of insects and to building up the collection. In cooperation with the botanist, he has carried on spraying experiments on plums and apples.

The botanist, in addition to the above spraying experiments, conducted five demonstration spraying experiments with iron sulphate for the eradication of wild mustard. He is studying the effect of iron sulphate on plants, and its action is believed to be due to dehydration resulting in plasmolysis of the cell contents. Considerable time is given to cytological studies of rust and alternate host plants of rust.

The station is carrying on a large amount of cooperative and demonstration work throughout the State. The Highmoor and Eureka substations are maintained by State funds, and two additional substations are provided for and are to be located before January 1, 1909. Farmers' institutes, short courses for farmers, and seed special trains are provided by the State and are well attended. An appropriation of $7,000 annually is made for farmers' institutes.

The publications received from this station during the past year were as follows: Bulletins 102, Evergreens for South Dakota; 103, Breeding hardy strawberries; and 104, Raspberries, strawberries, and dewberries; and the Annual Reports for 1906 and 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States, Adams Act	9,000.00
Miscellaneous, including balance from previous year	2,872.63
Total	26,872.63

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The South Dakota Station is carrying on valuable scientific work and actively disseminating the results of this work throughout the State.

TENNESSEE.

Tennessee Agricultural Experiment Station, *Knoxville.*

Department of the University of Tennessee.

H. A. Morgan, B. S. A., *Director.*

The recently completed agricultural building of the university furnishes good office and laboratory rooms for the experiment station. The amount appropriated by the State legislature for this building was $40,000. A like amount was appropriated for a substation in west Tennessee, but the location of this substation was not decided upon during the year. The cooperative work in middle Tennessee, for which the last legislature appropriated $10,000, was organized on a comprehensive plan. Considerable cooperative work was also carried on by the station in other parts of the State. This work has strengthened the station and the university in the State.

The station had four Adams fund projects under way during the past year, viz: Humus formation, life history and habits of the North American cattle tick, study of the peach borer, and new anthracnose of clover and alfalfa. Important advances have been made in all of these lines of investigation. A fifth project submitted, namely, a study of the hog louse, has not yet been taken up. The breeding of red clover immune to anthracnose has been very successful and an immune or highly resistant strain has been produced which will doubtless be of great practical value. The studies of the cattle tick are yielding results which are of the highest importance in connection with the active efforts which are being made to rid the State of this pest and remove the quarantine against tick fever in cattle. The chemist's work on the formation and composition of humus promises to throw considerable light on a little-known and complex subject.

Aside from the Adams fund work, the chemist and agronomist gave attention to the following subjects: A comprehensive study of the soils of the State; analyses of various crops grown on the station farm, to determine their plant food requirements; the preservative effect of rock phosphate on manure; chemical methods of determining the phosphoric-acid requirements of soils; tests of soils for acidity and lime requirements; field tests of wheat, oats, barley, corn, potatoes, alfalfa, red and alsike clover, soy beans, sorghum, and other forage plants; selection and breeding of corn; and rotation experiments with corn, wheat, and grass.

The botanist continued work in cotton breeding in cooperation with the Bureau of Plant Industry of this Department, investigating particularly the effect of altitude and change of seed and artificial mutations.

The director, with the assistance of the animal husbandman, continued experiments on the cost of production and the feeding value of acre plats of various crops, including up to the present corn, soy beans, and cowpeas.

Little veterinary work was undertaken, but study of sore mouth due to grazing and feeding on alsike clover was continued.

The bacteriologist of the station undertook a study of nitrogen assimilation with special reference to soy beans.

The station force cooperated with the department of agriculture of the State in institute work and with this Department in experiments with cereals, cotton and clover selection, and dairying.

The publications of the station received during the year were as follows: Bulletins 75, Selection for disease-resistant clover—a preliminary report; 76, The San José and other injurious scale insects of Tennessee, with methods for their control; 77, The fruiting habit of the grape; and 78, The soils of Tennessee, their chemical composition and fertilizer requirements; and the Annual Report for 1905.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Fees	1,000.00
Farm products	7,886.82
Total	32,886.82

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Tennessee Station continues to strengthen in organization and in both its scientific and practical work, and to grow in the esteem of the agricultural public of the State. Evidences of this are increased appropriations for agricultural purposes at the university, of which the station is a part, and a growing demand for cooperative work in other parts of the State.

TEXAS.

Texas Agricultural Experiment Station, *College Station.*

Department of the State Agricultural and Mechanical College of Texas.

H. H. Harrington, LL. D., *Director.*

The year was marked by a number of changes in personnel at the Texas Station. Early in the year the president of the college, H. H.

Harrington, was also made director of the station, with J. W. Carson assistant to the director and in charge of feed control. W. C. Welborn was elected vice-director and agriculturist. After the close of the year H. H. Harrington was succeeded as president of the college by R. T. Milner, but continues as director of the station. J. C. Burns, formerly assistant in animal husbandry, was placed in charge of this department, succeeding T. R. Marshall, who went to the Ohio State University. C. E. Sanborn, of the Bureau of Entomology of this Department, succeeded as entomologist A. F. Conradi, who went to the South Carolina Station.

Notwithstanding the numerous changes in staff the more important of the Adams fund projects enumerated in the last report were continued and considerable progress was made in several of them. Some features of the investigation on organisms assisting in the assimilation of nitrogen by leguminous plants have been reported upon and other data upon the same subject were prepared for publication. The soil studies were actively and very successfully prosecuted and were in part reported upon.[a] These investigations have heretofore related mainly to the phosphoric acid and potash of soils. They have shown the widespread deficiency of phosphoric acid in Texas soils and have thrown much light upon the conditions affecting the availability of the phosphoric acid of the soil. Investigations on the digestibility of the constituents of nitrogen-free extract of Texas feeding stuffs and on the southern grain aphis were practically completed during the year. The proposed investigations relating to tallow weed and a bacterial disease of cotton were abandoned, and the study of the primary proximate constituents of feeding stuffs was not taken up. Investigations on methods of combating stomach worms of cattle were replaced by studies of swamp fever (loin disease) in horses.

The following is a brief account of the more important lines of work in addition to the Adams fund investigations: The breeding of cotton for earliness and storm resistance, which has been going on for several years in cooperation with the Bureau of Plant Industry of this Department, continues to be an important feature of the work of the station. A variety of cotton has been developed in this work which promises to be valuable under improved methods of culture in combating the boll weevil. The station continued to cooperate with the Bureau of Plant Industry of this Department in experiments, mainly with forage crops, at Chillicothe, Tex., and also cooperated with the Bureau of Animal Industry in dairy work at Denison. Experiments with alfalfa, velvet beans, cowpeas, bur clover, hairy vetch, peanuts, and other forage plants are also in progress. The fertilizer requirements of cotton and alfalfa were studied.

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[a] Texas Sta. Buls. 99 and 100.

In addition to this work, the agriculturist engaged in a study of the general agricultural conditions of the State, the dissemination of popular agricultural information through press articles, in aiding in the introduction of agricultural instruction in the public schools, and in farmers' institutes, which are in charge of the State commissioner of agriculture.

Feeding experiments with cattle, using rations of cotton-seed meal and hulls, corn, Kafir corn, milo maize, and molasses, and with pigs, testing dry lot versus green feed and using combinations of peanuts, molasses, corn meal, and skim milk, were carried on. New cattle sheds for experimental work were built during the year and additions were made to the live stock.

In horticultural lines particular attention was given to propagation of pecans and Persian walnuts, peach culture, varieties and culture of plums, pears and grapes, resistant stocks for grapes, fertilizers for watermelons and cantaloups, rust-resistant cantaloups, marketing sweet potatoes, forestry planting, and miscellaneous tests of vegetables.

The veterinarian gave attention mainly to observations on loin disease of horses, but experimented with hemoglobin as a remedial agent in Texas fever. A veterinary hospital was built and should prove a valuable aid in veterinary investigations.

The entomologist carried on experiments in queen mating and with honey plants and studied the peach-tree borer, San José scale, and parasitic insects.

The botanist studied tomato rust, made examinations of seeds, and collected notes on plant diseases of the State.

The chemist continued to do the chemical work involved in the State inspection of fertilizers, feeding stuffs, and insecticides, and carried on various soil investigations supplementing those outlined as Adams-fund projects.

The publications received from the Texas Station during the year were as follows: Bulletins 93, The sweet-potato borer; 94, Horticultural survey of Gulf coast; 95, Information regarding the new feed law; 96, Commercial fertilizers and poisonous insecticides in 1906–7; 97, Kafir corn and milo maize for fattening cattle; 98, Summary—Texas Bulletins Nos. 1 to 94, inclusive; 99, The composition and properties of some Texas soils; 100, The chemical composition of some Texas soils; 101, Irish potato fertilizer experiments; 102, Texas honey plants; and 103, Forage crops in northwest Texas.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation for substations	7,000.00
Sale of cattle	1,185.08
Total	32,185.08

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The fees from inspection of feeding stuffs and fertilizers yield a net revenue of over $25,000 annually. This is being accumulated as a fund for the construction of an agricultural administration building, which it is expected will be begun in the near future and will furnish office rooms for the station.

In general it may be said that while the Texas Station has many important lines of work in progress which are yielding creditable results, its efficiency has, to some extent, been hampered by unsettled conditions.

UTAH.

Agricultural Experiment Station, *Logan.*

Department of the Agricultural College of Utah.

E. D. Ball, Ph. D., *Director.*

The year at this station was to a large extent one of readjustment in lines of work and organization.

The following staff changes occurred: George M. Turpin, formerly connected with the poultry investigations, was made assistant poultryman in charge of the poultry work; John Stephens, assistant agronomist, accepted a position in the Bureau of Plant Industry; following his resignation, the work in agronomy was rearranged; Professor Hogenson continued with the agronomic work on the home station as before, while L. A. Merrill, superintendent of extension work, was placed in charge of the arid farm experiments. W. W. McLaughlin resigned his position as irrigation engineer at the close of the year to take charge of the irrigation investigations in Utah of this Office. Since the close of the fiscal year, T. E. Woodward, of the Dairy Division of this Department, has been appointed dairyman.

Under the Adams fund three main lines of work are being pursued. In the poultry investigations much has been learned with reference to the relation of moisture and carbon dioxid in the incubator to the vitality of the chicks produced. Breeding experiments for egg production and the study of different methods of housing and feeding with reference to the vitality of chicks are also being carried on. The entomological department is studying the codling moth and certain insects of the sugar beet. The codling-moth investigation has resulted in a radical change in the methods of spraying for this pest. Two sprayings were recommended under this method some time ago, and they have been so successful in the hands of practical orchardists that the method is now almost universally used throughout the western region. Further investigations show that it is possible to control

this insect with only a single spraying. The investigation of the sugar-beet leaf hopper conclusively demonstrated that this insect is responsible for the diseased condition called "curly leaf" and methods were devised for predicting its appearance in injurious numbers and of preventing this injury. The chemical department is continuing its investigation of the movement of nitrates in the soil as affected by irrigation.

The station is cooperating with the Bureau of Plant Industry of this Department in the attempt to increase the sugar content of the sugar beet. Methods of siloing and of handling beet seed were improved until at the present time it seems probable that the industry of seed growing may be established on a commercial basis. The chemical department also investigated the chemical and milling qualities of Utah wheats. Growing interest in this investigation is shown, and already the better varieties are being taken up. The horticultural department is carrying on extended investigations of the value of different methods of pruning and thinning apples and peaches. An extensive investigation was also inaugurated into the nature and injury of crown-gall and hairy-root diseases. The animal husbandry department is carrying on feeding investigations on beef cattle, sheep, and hogs. The investigation of the value of pure-bred sires has already yielded valuable results. The calves from the pure-bred sires on even inferior stock are attracting much attention wherever exhibited. Work is being taken up in the breeding of draft horses and much interest has already been aroused in that work.

The irrigation and drainage investigations carried on in cooperation with the irrigation and drainage investigations of this Office were continued under State funds, $5,000 being appropriated by the State and $5,000 by this Office. The results of the entire five years' tests are being tabulated and it is already evident that many valuable results have been obtained. These will be prepared for publication as rapidly as possible, and the work will be revised on the basis of these results. Arid farming investigations have been continued under a State appropriation of $10,000, and in this work also the five years' results are being summarized and made ready for publication. The results already published have served to stimulate interest in this industry, and many thousands of acres have already been reclaimed and others are being taken up as fast as surveyed. In connection with this work the station, in cooperation with the Bureau of Plant Industry, has undertaken an extensive investigation into the development of better varieties of grains and grasses for the arid regions. Special attention is being paid to the selection and breeding of wheat varieties.

Two fruit stations, one at Lehi and one at St. George, are maintained under a State appropriation of $12,000. At these stations the

testing of different varieties of fruits and vegetables, pruning, thinning, and spraying experiments are now being carried on.

The following publications were received from this station during the fiscal year: Bulletins 100, Arid farming investigations; 101, Feeding experiments with cattle, sheep, swine, and horses; and 102, Poultry experiments.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	17,563.05
Farm products	5,065.81
Balance from previous year	3,114.02
Miscellaneous	400.00
Total	50,142.88

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

VERMONT.

Vermont Agricultural Experiment Station, *Burlington.*

Department of University of Vermont and State Agricultural College.

J. L. HILLS, Sc. D., *Director.*

No material additions to or changes in the lines of work under way at the Vermont Station were made during the past year. At the end of the year the assistant chemist, C. Cutler, resigned to go to the Indiana Station and was succeeded by H. L. Miner; later the dairy husbandman, C. L. Beach, resigned to become president of the Connecticut Agricultural College and was succeeded by R. M. Washburn, dairy commissioner of Missouri. H. V. F. de Thestrup was added to the station staff as gardener.

The projects carried on under the Adams fund were continued and substantial progress made in several instances, but no definite results were reached with any project. The lines which claimed most attention were: Studies of disease resistance of potatoes, Phytophthora disease of potatoes, the protein requirement of dairy cows, maintenance requirement of dairy cows, effect of milks of different qualities upon the structure of the young animal, studies of the cause of maple-sap fermentation, causes of a melon rot, the anesthesia of plants, and carnation breeding. The Phytophthora and disease resistance work, which are among the most important lines of work at the station, have been considerably retarded by the fact that for several successive

years the disease has not appeared. This work is carried on in coöperation with the Bureau of Plant Industry of this Department.

A small building for animal experimentation was built during the year, devoted to feeding experiments with pigs and calves. Considerable new equipment was procured for the chemical and veterinary laboratories.

The following publications were received from this station during the fiscal year: Bulletins 128, The testing of cows; 129, Abstract of Nineteenth Annual Report, 1905–6.; 130, Commercial fertilizers. Soil biology in its relation to fertilization; 131, Commercial feeding stuffs; 132, Forest planting in Vermont; 133, Commercial feeding stuffs; and 134, Commercial fertilizers; and the Annual Report for 1906.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	1,033.10
Individuals	113.04
Fees	2,729.48
Total	27,875.62

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

VIRGINIA.

Virginia Agricultural Experiment Station, *Blacksburg*.

Department of Virginia Agricultural and Mechanical College and Polytechnic Institute.

S. W. Fletcher, Ph. D., *Director*.

Changes occurred during the year in the head of this station and in several members of the staff. The station was without an active head from July, 1907, to January, 1908. A. M. Soule was succeeded as director by S. W. Fletcher, of the Michigan Agricultural College and Experiment Station. W. J. Quick was made dean of the college of agriculture and animal husbandman in the station, with A. P. Spencer as assistant animal husbandman. L. E. Carrier, of the Bureau of Plant Industry of this Department, was appointed agronomist. Shortly after the close of the year W. J. Quick resigned as dean of the college of agriculture and was succeeded by H. L. Price, horticulturist of the station. Howard S. Reed, of the Bureau of Soils of this Department, was made plant pathologist, succeeding Meade Ferguson, who accepted the position of bacteriologist of the State board of health. W. K. Brainerd, formerly of the West Virginia University, was appointed dairyman vice W. D. Saunders, who became State dairy and food commissioner.

Three of the Adams fund projects enumerated in the last report, namely, fixation of phosphoric acid by soils, breeding experiments with apples, and relation of meteorological conditions to blooming periods of fruit, were actively prosecuted during the year. Toward the close of the year the following projects were submitted and approved: The relation of soil environment to fruit-bud formation; bud variation of the strawberry; cause of self-sterility in fruits; effect of methods of treatment and grazing on the growth, yield, and permanency of pasture grasses (in cooperation with the Bureau of Plant Industry of this Department); and curative treatment of tuberculosis (in cooperation with the Bureau of Animal Industry).

The station carried on a considerable amount of important experimental work aside from the Adams fund projects. This included in the chemical department a study of the nutritive value of native Virginia grasses and forage plants and a comparison of the fertilizing value of different phosphates.

In the horticultural department the investigations on inheritance as related to Mendel's law in case of tomatoes, which have been carried on for a number of years, were practically completed during the year, and the results have been published. Experiments were also continued with dwarf varieties of apples to test their commercial value, and with French varieties of apples to test their value for cider making. Miscellaneous tests of varieties of vegetables were carried on as heretofore.

A large amount of new work in agronomy was undertaken during the year. This included acclimatization of corn from different parts of Virginia and from other States, improvement of seed potatoes, the improvement of sweet-corn seed, rotation and fertilizer experiments with different crops, and tests and improvement of various grasses and forage plants.

In the department of animal husbandry information relating to the sheep industry in Virginia was collected, and feeding experiments were made with rations of silage and hay with corn-and-cob meal, cotton-seed meal, and bran for finishing steers for the market; with a succession of green crops and with rations of hard and soft corn and blood meal and skim milk for hogs; and with various substitutes for milk for calves. Experiments in breeding sheep for the production of fall lambs were also undertaken.

The following publications were received during the year: Bulletins 165, The improvement of corn; 166, The improvement of fire-cured tobacco; 167, Corn and various amendments as food for hogs; 168, Experiments with oats, millet, and various legumes; 169, Protein requirements for dairy cows; 170, Studies in milk and butter production; 171, The development of grade and cross-bred beef cattle; 172,

Grains to supplement skim milk for calves; and 173, Finishing beef cattle.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	5,000.00
Balance from previous year	151.77
Farm products	625.55
Miscellaneous, including balance from previous year	622.51
Total	30,399.83

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The work of this station suffered to some extent from unsettled conditions resulting from numerous changes in organization and personnel during the year. The new director has, however, succeeded in outlining and inaugurating a number of important lines of investigation, extended cooperation between the station and this Department and with other agencies in the State, and, in general, in putting the work of the station on a good basis for future development.

Virginia Truck Experiment Station, *Norfolk.*

Cooperating with the Virginia Agricultural Experiment Station and the United States Department of Agriculture.

T. C. Johnson, B. S. Agr., M. A., *Superintendent.*

The Virginia Truck Station was organized in February, 1907, under the control of a governing board of six members, two representing the State board of agriculture and immigration, two the Virginia Polytechnic Institute and Agricultural Experiment Station, and two the truck growers of tidewater Virginia. At a meeting of this board, June 5, T. C. Johnson, of West Virginia University, was elected superintendent and assumed his duties September 24.

The station was located at Norfolk, where local truck growers, through the Southern Produce Company, had donated the use of a 58-acre truck farm and contributed $7,500 for the erection of buildings and $100 to assist in working out effective means of controlling certain potato insects. In the spring of 1908 contracts were let for a barn, laboratory, and residence, and these have since been completed.

The station is actively cooperating with this Department and has organized a cooperating staff, consisting of L. C. Corbett and W. A. Orton, of the Bureau of Plant Industry, and F. H. Chittenden, of the Bureau of Entomology. The station staff also includes assistants in entomology and truck crops.

The lines of work taken up thus far in cooperation with the Bureau of Plant Industry include studies of the fertilizer requirements of the principal truck crops on the Norfolk sandy loam and of plant diseases as induced by malnutrition, and in cooperation with the Bureau of Entomology there are studies of the principal truck insects. It is believed that methods of control for several important insect pests of cabbage have been discovered.

Aside from the cooperative work, attention is being given to plant breeding with special reference to strawberries and peanuts, to studies of the more important fungus diseases affecting cucurbits, and to demonstrations of means of control of insects and fungus pests affecting truck crops. As a result of this work it is announced that practical control of the downy mildew and anthracnose of cucumbers and cantaloups has been secured.

No publications have as yet been received from this station.

The station is maintained chiefly by annual appropriations of $5,000 each from the State legislature and the State board of agriculture and immigration, together with contributions from truck growers of the region. During the past fiscal year the income was as follows:

State appropriation	$5,000.00
State board of agriculture and immigration	5,000.00
Individuals	[a]100.00
Total	10,100.00

WASHINGTON.

Washington Agricultural Experiment Station, *Pullman.*

Department of the State College of Washington.

R. W. Thatcher, B. S., M. A., *Director.*

The Washington Station has undergone considerable reorganization during the past year and is now in a position to develop greater efficiency than ever before. The more complete separation of the station work from that of the college is a benefit to both station and college.

Progress is reported upon the various Adams fund projects outlined in the report for 1907, and three new ones have been approved. These include a study of soil toxicity, Mendelism in hybrids of blackberries and raspberries, and the effect of nutrition upon the development, maturity, and prolificacy of swine. Distinct advance is reported in the cereal-breeding work, and a number of hybrids have been produced whose nitrogen content is considerably higher than the

[a] Besides $7,500 for the erection of buildings.

average. It is believed that the principles underlying the distribution of nitrogen in the wheat plant have been discovered, and, if confirmed, a proper basis for breeding for high nitrogen content will be secured. An assistant has been secured in the department of botany, who will give especial attention to the tomato-blight investigation. The veterinary department reports the discovery of a disease that will rapidly destroy spermophiles when fed to them in cultures, but thus far it has been impossible to cause the disease to spread from animal to animal. The project relating to soil moisture suffered the loss of all records through fire, but the work has been actively renewed. Some work is being carried on on all the projects, although definite results have not been announced on them.

The botanist has made some physiological studies on the toxic principles of soils in their relation to root action.

Among the other more important lines of work are: Spraying experiments with lime-sulphur for the control of apple scab; efficiency of lime-sulphur as compared with Bordeaux mixture as a fungicide; resistance of various plants to disease; testing of vegetables under market gardener's conditions; vegetable seed production; variety testing of potatoes; introduction of varieties of ornamental shrubs and vines; cover crops for orchards; shade and forest trees for planting in the State; spring versus summer pruning of orchard trees; completing fifteen years' work in testing varieties of apples; plant breeding with orchard and small fruits; hybridizing tomatoes; codling-moth control; testing different strengths of lime-sulphur mixture; wheat-straw worm (*Isosoma* sp.); oyster-shell bark-louse; grasshoppers; climbing cutworms; effect of nutrition on heredity and breeding habits of swine; and movement of water and salts in soils.

There has also been a study of the rate of transmission of tuberculosis from diseased to healthy cattle; of the reliability of the tuberculin test for tuberculosis in hogs; an investigation of the composition of western Washington milks; and studies of the cider-making value of Washington apples.

The station is carrying on considerable demonstration work in various parts of the State, the funds being supplied from State appropriation for farmers' institute work and from local assistance. This work includes principally spraying experiments, irrigation and dry-land farming, dairying, diversified agriculture, and orcharding.

Three cooperative experimental farms have been established in different localities of the State, the object being to study the possibilities of intensive diversified farming in these localities. Cooperative work with the Bureau of Plant Industry in the introduction of forage crops and with the Bureau of Entomology in the study of wheat insects has been started.

A special farming-demonstration train was run through Whitman County on March 5 and 6, with one-hour stops at fourteen towns. Over 2,800 people visited the train, examined the exhibits, and listened to lectures by members of the station staff on improved methods of farming. A special fruit-demonstration train was also sent out over the lines of an electric railway in eastern Washington, March 27–28, with thirty-minute stops at twenty towns, and an attendance of about 1,900 fruit growers. Lectures and demonstrations were given on methods of combating the codling moth and apple scab, and on orchard cultivation. It is believed that this is the first fruit-demonstration train ever operated, and also the first electric train to be used for demonstration purposes. The results of the trip are regarded as highly satisfactory, and the work is meeting with the hearty approval of the farmers of the State.

The college is in a very prosperous condition and a number of new buildings are in course of erection or are ready for occupation. Among them are a library and auditorium building to cost $135,000; a recitation building, $125,000; a domestic science building and one wing of veterinary building, together costing $30,000; a material-testing laboratory, $5,000; and a new barn, $7,000. In addition, land has been purchased to add to the farm, costing about $12,000. The new recitation building will relieve some of the crowding in the agricultural building and others where station men are located.

The following publications have been received from this station during the year: Bulletins 82, I, The chemical composition of Washington forage crops. II, Analyses of grains and concentrated feeding stuffs; 83, Some important plant diseases of Washington; 84, Wheat and flour investigations; 85, Washington soils; and 86, The codling moth in 1907; Popular Bulletins 1, Announcements; 2, The sulphur-lime wash; 3, Pruning fruit trees; 4, Notes on swine management; and 5, Spraying for the codling moth.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Farm products	2,059.42
Total	26,059.42

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Washington Station is carrying on a number of investigations of considerable scientific and practical importance and is making the farmers of the State acquainted with the results of station work in a very active manner.

WEST VIRGINIA.

West Virginia Agricultural Experiment Station, *Morgantown.*

Department of West Virginia University.

J. H. Stewart, M. A., *Director.*

The work at the West Virginia Station during the past year has been mainly a continuation of the investigations previously outlined and considerable definite progress has been made.

In addition to the work undertaken under the Adams Act as stated in the report for 1907, investigations in the following lines were included in the projects approved during the past year: The artificial fixation of atmospheric nitrogen, the causes of variation in the apple and the peach, and studies of the short-tailed shrew. The studies of apple and clover diseases were suspended on account of the withdrawal of the bacteriologist. The investigation of the short-tailed shrew has involved the collection of a considerable number of stomachs, and observations have also been made on the relations of this animal to ground-nesting birds. Some of the results of this work have been published in Bulletin 113. Important observations have been made on some beetles and a brief paper on this subject was published in the report of the station for last year. The study of the causes of mortality of brooder chicks has included temperature and moisture observations, from which a considerable amount of data has been accumulated. In the horticultural project only preliminary work was done. Additional land and facilities are being acquired for this work.

In the department of chemistry considerable work has been done on a new artificial incubation of eggs. The study of the soils of the State with reference to acidity has been continued, and work has been done on the treatment of peach trees with various chemicals in the hope of preventing yellows. An assistant has been located at the station by the State geological survey.

The following are some of the lines of work of the horticulturist: A potato investigation to study variation under different climatic and cultural conditions, to determine, for example, if high altitudes will produce superior potatoes for seed, and to study diseases and enemies. A station for this work has been established at Preston, at an altitude of 1,800 feet, and a field for similar work has been selected in the Ohio Valley.

Spraying experiments for leaf-spot diseases and bitter rot of apples have been conducted in an orchard in the Panhandle region. This is largely demonstration work, but the marked results of the spraying have attracted considerable attention. Fertilizer experiments are

also in progress in an outside apple orchard with reference to the effect on fungus diseases of the apple, especially leaf spot, in an apple orchard near Martinsburg.

Tomato experiments with special reference to the use of this crop in young orchards are being conducted. A spray calendar for West Virginia has been sent out. Much time has been spent in visits to horticultural regions of the State, partly to study conditions there and partly to aid the horticulturists in organizing and establishing new orchards. Efforts have also been made to secure the replanting of peach trees in regions formerly infested with yellows near Romney.

A knowledge of proper practices on the part of peach orchardists for the control and eradication of peach yellows has become prevalent among people so engaged by reason of the inspection work of the station. Inspection of orchards for San José scale has been carried on extensively, and the owners of orchards infested with this scale have rapidly increased their facilities and are practicing the best methods prescribed for controlling it. During the past two years about a million and a half of peach trees were inspected from one to four times. The rate of infection of these orchards by peach yellows has been about 6 per cent.

In the cross-breeding tests with registered Jerseys and Ayrshires many valuable data have been accumulated. In connection with this investigation it is intended to make crosses on Jerseys with a Kerry bull, imported from Ireland, where this breed of cattle is held in much favor for the production of milk. In this way it will soon be possible to determine the practical value of crosses of Kerrys on Ayrshires for dairy purposes.

Tests have been carried on to determine the relative value of green cowpea vines and grain for milk production in the fall when pasture has become short.

The station is undertaking the testing of dairy herds in various portions of the State in response to the request of the national associations of breeders of the various dairy types.

Tests have also been made of Angora goats as brush destroyers, and some valuable observations have been made.

A long-time investigation regarding the fertilizer requirements of the soil of the experiment farm has been continued. The results of this test are becoming yearly more valuable and instructive.

The entomologist has made special studies on the physiological effect of oil on apple and pear trees. An investigation of the habits, life-history, and further means of control of the peach-tree borer has also been made.

The fertilizer inspection work of the station has gone on as usual.

Cooperative work has been carried on with farmers in the production of varieties of pure-bred poultry, and in tests of methods for eradicating internal parasites of sheep. These parasites have been the greatest obstacles to successful sheep husbandry in West Virginia.

During the past year the poultry plant of the station has been increased through the erection of a long house (24 by 64 feet in dimensions) built on the open-front or fresh-air plan. The object of this building is to determine whether houses of this sort are more suitable for West Virginia conditions than houses of the closed front or curtain type, many of which have been built in this State in recent years.

Eight bulletins have been received from this station during the year, as follows: Bulletins 109, Feeding grain to milch cows at pasture; 110, The grapevine root borer; 111, Bacteria in milk and artificial refrigeration for dairymen; 112, Experiments with fertilizers; 113, Notes on the habits of mice, moles, and shrews; 114, Commercial fertilizers; 115, Poultry experiments; and 116, Starting young orchards.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	10,000.00
Fees	9,151.09
Farm products	6,562.56
Total	49,713.65

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The West Virginia Station is pursuing work along a number of lines of much importance to the agriculture of the State. There has been considerable increase of interest in its operations and a growing demand for information. There is still need of the stronger organization of the agricultural forces of the State to support both the station and the college in enlarging the opportunities and facilities for agricultural education.

WISCONSIN.

Agricultural Experiment Station of the University of Wisconsin, ***Madison.***

Department of the University of Wisconsin.

H. L. Russell, Ph. D., *Director.*

The work of this station is well organized, and was prosecuted with vigor during the past year. Practically no changes were made dur-

ing the year in heads of departments, but a number of changes were made in assistants on the station staff. An editor, J. C. Marquis, was added to the station staff. It will be his duty to edit bulletins and reports of the station and to have charge of the general publicity work of the station and college. The improvement of the buildings and other structures on the hill farm and the construction of a large concrete stock-judging pavilion to cost $75,000 were begun during the year.

Work was actively prosecuted on all of the Adams fund projects referred to in the last report. The study of the milking machine was completed and the results have been published.[a] Work on this subject has been discontinued. The results obtained were generally favorable to the use of the milking machine under suitable conditions and proper management. Investigations on the leucocytes in milk and their sanitary significance were practically completed during the year. The results obtained in this investigation show quite clearly that the leucocyte count is not a reliable basis for judging the sanitary condition of milk. The first phase of the investigation on mineral constituents of feeding stuffs in relation to the growth and development of farm animals, namely, the effect of inorganic calcium phosphate in the rations of growing swine, was completed during the year. A new project growing out of the previous work of the station, namely, the relation of different systems of farming to phosphates in the soil and the conditions affecting the availability of the phosphates, was taken up during the year.

Aside from the Adams fund projects, experiments on the effect of high and low protein rations were continued with a herd of 30 cows. Feeding experiments with sheep and swine were also made.

The efforts to improve the quality of horses in the State by registration of stallions under the State law were continued with much success.

The selective breeding of cereals, particularly corn, oats, rye, and barley, and the distribution of improved seed (especially of barley) continue to be important features of station work.

The improvement of tobacco by breeding and selection, the breeding of blight-resistant potatoes, and cooperative experiments with potatoes were continued, and experiments in the production of alcohol potatoes and with insecticides were undertaken.

The cranberry investigations at Cranmoor were continued, including studies of injurious insects, sanding, drainage, and various means of preventing frost.

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[a] Wisconsin Sta. Bul. 173.

The study of the dissemination of tuberculosis was continued along the lines followed in previous years.

Experiments in the improvement of typical soils in different parts of the State were carried on as heretofore. Such experiments are now carried on cooperatively at Sparta and Iron River on sandy soils; at Mather, Marinette, and Phillips on peat soils; and at Superior and Ashland on heavy clay soils.

The butter and cheese scoring exhibitions inaugurated by the station are proving useful in stimulating interest in the improvement of these products.

The inspection work of the station is extensive, covering fertilizers, feeding stuffs, nurseries, seeds, official dairy tests, and licensing stallions.

The publications received from the station during the year were as follows: Bulletins 151, Condimental stock foods; 152, A comparison of aniline and anatto butter colors in butter making; 153, Portable hog houses; 154, A creamery method for the determination of water in butter; 155, The distribution of stallions in Wisconsin; 156, A simple test for casein in milk and its relation to the dairy industry; 157, Licensed commercial feeding stuffs, 1907; 158, The grade stallion situation in Wisconsin; 160, Tests of dairy cows, 1906–7; 161, Grains and forage crops for northern Wisconsin; 162, Rusty cans and their effect upon milk for cheese making; 163, Licensed commercial fertilizers, with list of licensed feeding stuffs, 1908; Special Bulletins—Tuberculosis of domestic stock and its control, and The seeding, growing, and curing of alfalfa; and the Annual Report for 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
State appropriation	18,500.00
Fees	8,843.87
Total	51,343.87

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

As a result of good organization, efficient administration, and an able staff, the Wisconsin Station continues to do work of a high grade from both the practical and the scientific standpoint. The improvement of the scientific quality of the work has gone hand in hand with an increase in its practical usefulness to the agricultural interests of the State.

WYOMING.

Wyoming Agricultural Experiment Station, *Laramie*.

Department of the University of Wyoming.

J. D. Towar, M. S., *Director*.

Many changes occurred at this station during the past year, and conditions were therefore unsettled. J. D. Towar was appointed director, vice B. C. Buffum, who has gone into private business at Worland, Wyo.; L. B. McWethy was made agronomist; A. D. Faville was made animal husbandman, vice T. F. McConnell; J. C. Fitterer succeeded H. T. Nowell as irrigation engineer; and a veterinarian, O. L. Prien, was added to the station staff. The botanist was transferred entirely to university work during the year. J. D. Towar had been acting president of the university until C. O. Merica was elected president May 9, 1907.

Considerable progress was made during the year in reclaiming the seeped and alkali land of the penitentiary farm (in cooperation with this Office) and in fitting up the penitentiary building and grounds for experimental purposes. One end of the building was made into a cow barn, the other fitted up for the wool investigations. Fences, corrals, etc., were also built. The last legislature gave $5,000 for such improvements.

Attention was practically confined during the year to two Adams fund projects, namely, wool investigations and soil moisture investigations. The various botanical investigations referred to in last year's report were discontinued as Adams fund projects.

The station was very unfortunate in having practically all of its experimental field crops destroyed by hail during the summer of 1908. This involved in some cases the loss of the results of several years' work, particularly in the plant-breeding experiments.

While the results of the past season's (1908) work were lost, the agronomist has outlined a number of promising lines of work for the future. Horticultural work has been temporarily abandoned.

The extensive experiments in the breeding and management of range sheep, in cooperation with the Bureau of Animal Industry of this Department, were continued. In connection with this work some tests of the most economical rations for sheep were made; also similar tests with cattle. The breeding of polled Herefords was continued. Study of the composition and digestibility of native forage plants was also continued.

The publications of the station received by the Office during the year were: Bulletins 73, Ration experiments with lambs; 74, Ration experiments with swine; 75, The life and preservation of pitch-pine

fence posts; 76, Wyoming forage plants and their chemical composition—Studies No. 3; Index Bulletin D; and the Annual Reports for 1906 and 1907.

The income of the station during the past fiscal year was as follows:

United States appropriation, Hatch Act	$15,000.00
United States appropriation, Adams Act	9,000.00
Farm products	1,311.59
Total	25,311.59

A report of the receipts and expenditures for the United States funds has been rendered in accordance with the schedules prescribed by this Department and has been approved.

The Wyoming Station made some improvements in equipment during the year and continued work on a few promising lines of investigation, but conditions were unsettled and therefore unfavorable to a vigorous and consistent policy.

STATISTICS OF LAND-GRANT COLLEGES AND AGRICULTURAL EXPERIMENT STATIONS, 1908.

By Miss M. T. Spethmann.

The following statistical statements relate to the institutions established under the acts of Congress of July 2, 1862, and August 30, 1890, most of which maintain courses of instruction in agriculture, and to the agricultural experiment stations, which, with few exceptions, are organized under the act of Congress of March 2, 1887, and are conducted as departments of the institutions receiving the benefits of the land-grant act of 1862. These statistics have been compiled in part from the annual reports of the presidents of these institutions made on the schedules prescribed by the Commissioner of Education. Tables showing the annual disbursements on account of the acts of Congress of March 2, 1887, August 30, 1890, March 16, 1906, and March 4, 1907, prepared from figures furnished by the Departments of the Treasury and the Interior, are also included. Owing to the complex organization of many of the institutions, it is impracticable to give exactly comparable statistics in all cases, and in some instances the data furnished are incomplete.

SUMMARY OF STATISTICS OF LAND-GRANT COLLEGES.

Educational institutions receiving the benefits of the acts of Congress of July 2, 1862, August 30, 1890, and March 4, 1907, are now in operation in all the States and Territories except Alaska. The total number of these institutions is 67, of which 64 maintain courses of instruction in agriculture. The aggregate value of the permanent funds and equipment of the land-grant colleges and universities in 1908 is estimated to be as follows: Land-grant fund of 1862, $13,010,284.52; other land-grant funds, $3,460,801; other permanent funds, $18,726,387.04; land grant of 1862 still unsold, $6,997,485.27; farms and grounds owned by the institutions, $12,004,682.77; buildings, $37,401,578.51; apparatus, $3,532,099.85; machinery, $2,121,291.35; libraries, $3,585,828.69; live stock, $937,016.21; miscellaneous equipment, $4,565,224.61; total, $106,342,679.82. The income of these institutions in 1908, exclusive of the funds received from the United States for agricultural experiment stations ($1,089,600), was as follows: Interest on land-grant funds of 1862, $737,730.43; interest on other land-grant funds, $112,772.22; United States appropriation under acts of 1890 and 1907, $1,500,000; interest on endowment or regular appropriation,

$299,787; State appropriation for current expenses, $5,230,770.67; State appropriations for buildings or for other special purposes, $4,819,067.73; income from endowment, other than Federal or State grants, $828,456.40; tuition fees, $1,070,782.02; incidental fees, $860,744.35; miscellaneous, $2,778,682.03; total, $18,238,792.85. The value of the additions to the permanent endowment and equipment of these institutions in 1908 is estimated as follows: Permanent endowment, $1,538,904.75; buildings, $3,705,100.10; libraries, $225,399.17; apparatus, $334,507.20; machinery, $232,392.58; live stock, $73,356.78; miscellaneous, $297,321.55; total, $6,406,982.13.

The number of persons in the faculties of the colleges of agriculture and mechanic arts was as follows: For preparatory classes, 689; for collegiate and special classes, 2,878; total, counting none twice, 3,362. In the other departments the faculties aggregated 2,050, making a grand total of 5,412 persons in the faculties of the land-grant institutions.

The students in 1908 in the colleges for white persons were as follows: (1) By classes—preparatory, 6,684; collegiate, 25,997; short course or special, 13,593; postgraduate, 788; other departments, 21,081; total, counting none twice, 67,209. (2) By courses: *Four-year*—agriculture, 4,176; horticulture, 189; forestry, 131; veterinary science, 207; household economy, 1,473; engineering, 18,437. *Shorter than four years*—mechanic arts, 905; agriculture, 4,997; horticulture, 272; forestry, 97; dairying, 709; veterinary science, 298; household economy, 566; two-year teachers' course in agriculture, 174; summer school of agriculture for teachers, 1,044; military tactics, 19,199.

The students in colleges and schools for colored persons were as follows: (1) By classes—preparatory, 4,761; collegiate, 865; short or special, 312; other departments, 797; total, 6,738. (2) By courses—agriculture, 2,336; industrial courses for boys, 2,307; industrial courses for girls, 4,849; military tactics, 1,694.

The graduates in 1908 were 6,282, and since the organization of these institutions, 78,749. The average age of graduates in 1908 was 22 years and 1 month. The total number of volumes in the libraries was 2,144,180, and the total number of pamphlets, 609,267. The total number of acres of land granted to the States under the act of 1862 was 10,570,842, of which 1,010,439 are still unsold.

SUMMARY OF STATISTICS OF THE STATIONS.

Agricultural experiment stations are now in operation under the acts of Congress of March 2, 1887, and March 16, 1906, in all the States and Territories and under special appropriation acts in Alaska, Hawaii, and Porto Rico.

In Connecticut, New Jersey, New York, Hawaii, Missouri, Alabama, Louisiana, and North Carolina separate stations are main-

tained wholly or in part by State funds. A number of substations are also maintained in different States. Excluding the substations, the total number of stations in the United States is 61. Of these 55 receive appropriations provided for by acts of Congress.

The total income of the stations maintained under the acts of 1887 and 1906 during 1908 was $2,800,047.29, of which $1,152,000 (Hatch fund $720,000, Adams fund $432,000) was received from the National Government, the remainder, $1,648,047.29, coming from the following sources: State governments, $947,558.67; individuals and communities, $22,835.30; fees for analyses of fertilizers, $186,159.70; sales of farm products, $210,391.28; miscellaneous, $281,102.34. In addition to this the Office of Experiment Stations had an appropriation of $293,220 for the past fiscal year, including $24,000 each for the Alaska, Hawaii, and Porto Rico experiment stations, $5,000 for nutrition investigations, $150,000 for irrigation and drainage investigations, and $5,000 for farmers' institutes and agricultural schools. The value of the additions to the equipment of the stations in 1908 is estimated as follows: Buildings, $407,723.69; libraries, $26,235.16; apparatus, $51,549.56; farm implements, $33,106.93; live stock, $54,555.02; miscellaneous, $181,455.65; total, $574,626.01.

The stations employ 1,143 persons in the work of administration and inquiry. The number of officers engaged in the different lines of work is as follows: Directors, 55; assistant and vice-directors, 21; special agents in charge, 3; chemists, 127; agriculturists, 145; agronomists, 107; plant breeders, 11; animal husbandmen, 79; animal nutrition, 14; poultrymen, 7; horticulturists, 114; pomologists, 5; farm and garden foremen, 31; dairymen, 60; botanists, 71; plant pathologists, 34; entomologists, 96; zoologists, 6; veterinarians, 36; animal pathologists, 4; meteorologists, 12; foresters, 15; mycologists, 3; biologists, 8; physicists, 10; geologists, 3; bacteriologists, 40; irrigation engineers, 13; agricultural engineers, 11; in charge of substations, 24; secretaries and treasurers, 31; and librarians, 13. There are also 50 persons classified under the head "Miscellaneous," including superintendents of grounds and buildings, gardeners, farm mechanics, laboratory and field assistants, etc. Four hundred and ninety station officers do more or less teaching in the colleges with which the stations are connected. During the year the stations published 499 annual reports, bulletins, and circulars, which were supplied to about 889,000 addresses on the regular mailing lists. A larger number of stations than formerly supplemented their regular publications with more or less frequent issues of press bulletins and other special publications, and most of the stations report a large and constantly increasing correspondence with farmers on a wide variety of topics.

STATISTICS OF THE LAND-GRANT COLLEGES AND UNIVERSITIES.[a]

Unless otherwise specified, the statistics reported in the tables are for the institutions as designated in the list given below:

TABLE 1.—*Institutions established under the land-grant act of July 2, 1862, and their courses of study.*

[All of the institutions in this list, except those marked with an asterisk (*), maintain courses of instruction in agriculture.]

State or Territory.	Name of institution.	Location.	President.	Collegiate courses of study (undergraduate). Degree courses.[b]	Collegiate courses of study (undergraduate). Preparatory and short courses.
Alabama	Alabama Polytechnic Institute.	Auburn	C. C. Thach, M. A., LL. D.	Agr., civil engin., archi., elect. engin., mech. engin., mining engin., phar., general, chem. and metal. (B. S.); phar. (2 yrs., Ph. G., 3 yrs., Ph. C.); vet. med. and surgery (3 yrs., D. V. M.).	Agr., mech. arts (2 yrs.), agr. (1 yr.), summer school for farmers (10 days).
	Agricultural and Mechanical College for Negroes.	Normal	W. H. Councill, Ph. D.	Sci. (B. S.), agr. (B. A. S.), mech. (B. M. S.).	Indus. and lit. studies (1 to 4 yrs.).
Arizona	University of Arizona	Tucson	K. C. Babcock, Ph. D.	Lit. (Ph. B.), sci., metal., mining engin., civil engin., mech. engin. (B. S.).	Mineralogy and assaying (2 yrs.), music.
Arkansas	University of Arkansas	Fayetteville	J. N. Tillman, LL. D.	Agr. (B. S. A.), mech. engin. (B. M. E.), elect. engin. (B. E. E.), civil engin. (B. C. E.), mining engin. (B. Mi. E.), chem. engin. (B. Ch. E.), chem. (B. S. C.), lit. and sci. (B. A. and B. S.), music (B. Mus.).	Agr., hort., dairying, elect. engin. (2 yrs.), mech. arts (2 or 3 yrs.), prep. (2 yrs.), agr. (2 weeks), art (1 yr. and 4 yrs.), normal (4 yrs.).
	*Branch Normal College.	Pine Bluff	Isaac Fisher	Clas. (B. A.)	Normal (4 yrs., L. I.), prep. (2 yrs.), manual training, mech. arts.
California	University of California	Berkeley	B. I. Wheeler, Ph. D. LL. D.	Letters (B. A.), social sci. (B. L.), natural sci., commerce, agr., mech. engin., elect. engin., mining engin., civil engin., chem., sugar technol. (B. S.).	Agr., animal indus., dairying (6 weeks), nutrition (3 weeks), ent. (4 weeks), vit. (4 weeks), summer session (6 weeks).
Colorado	The State Agricultural College of Colorado.	Fort Collins	B. O. Aylesworth, M. A., LL. D., Litt. D.	Agr., mech. engin., civil and irrig. engin., elect. engin., general and domestic sci., hort., general sci. for women, forestry (B. S.), vet. sci. (D. V. S., 3 yrs.).	Agr., domestic sci. (2 yrs. of 5 months each), mech. arts (2 yrs.), farriery.
Connecticut	Connecticut Agricultural College.	Storrs	C. L. Beach, B. S., B. Agr.	Agr. (B. S.)	Dairying, poultry culture, and hort., mech. arts, home econ. (3 courses 2 or 4 yrs. each, diploma), summer school for teachers in nature study and agriculture (4 weeks), dairying, pomol. (winter, 12 weeks), poultry, forestry (6 weeks).

Delaware	Delaware College	Newark	G. A. Harter, M. A., Ph. D.	Clas., Lat. sci. (B. A.), agr., general sci., civil engin., mech. engin., elect. engin. (B. S.).	Agr. (4 or 2 yrs.), agr. (winter, 1 week).
	State College for Colored Students.	Dover	W. C. Jason, A. M., D. D.	Sci. (B. S.), agr. (B. Agr.), engin. (B. E.)	Normal (3 yrs.), industrial (2 yrs.), prep.
Florida	University of the State of Florida.	Gainesville	Andrew Sledd, Ph. D., LL. D.	Lit. (B. A.), gen. sci., agr., mech. engin., elect. engin., civil engin. (B. S.), pedag. (B. A. in Ped.).	Agr., mech. arts, pedag. (2 yrs.), prep. (1 yr.), summer school for teachers (6 weeks), corresp. course in agr. for teachers.
	Florida State Normal and Industrial School.	Tallahassee	N. B. Young, M. A.	Sci. (B. S.)	Normal (2 yrs.), high school (3 yrs.), grammar school (3 yrs.), indus. training through all courses.
Georgia	Georgia State College of Agriculture and Mechanic Arts.	Athens	A. M. Soule, B. S. A.	General sci., agr., civil engin., elect. engin. (B. S.), phar. (2 yrs., Ph. C.).	Agr., hort., dairying (1 yr.), agr. (winter, 12 weeks), cotton school (10 days).
	Georgia State Industrial College.	Savannah	R. R. Wright, A. M., LL. D.	Collegiate (A. B.)	Normal (3 yrs.), industrial, prep. (3 yrs.), dairying (winter, 2 months).
Hawaii	College of Hawaii	Honolulu	J. W. Gilmore, M. S. A.	Sci., agr., home econ., engin. (B. S.)	Agr. (6 weeks).
Idaho	University of Idaho	Moscow	J. A. MacLean, Ph. D., LL. D.	Clas. (B. A.), sci. (B. S.), agr. and hort., (B. S. Agr.), domestic econ. (B. S. D. E.), civil engin. (B. S. C. E.), mining engin. (B. M. M. E.), elect. engin. (B. S. E. E.), music (B. M.).	Agr. (4 yrs.), prep. (3 yrs.), dairying (special, 1 yr.), dairying and hort. (winter, 4–6 weeks).
Illinois	University of Illinois	Urbana	E. J. James, Ph. D., LL. D.	Lit. and arts (B. A.), archi. engin., civil engin., elect. engin., mech. engin., railway engin., municipal and sanitary engin., sci., agr., domestic sci., landscape gard. (B. S.), music (B. M.), libr. sci. (B. L. S.), med. (M. D.), dentistry (3 yrs., D. D. S.), phar. (2 yrs., Ph. G.), law (3 yrs., LL. B.), phar. chem. (2 yrs., Ph. C.)	Summer school, including secondary and el. agr. for rural teachers (6 weeks), agr. and domestic sci. (2 weeks).
Indiana	Purdue University	Lafayette	W. E. Stone, Ph. D., LL. D.	Mech. engin. (B. S. M. E.), civil engin., sanitary engin. (B. S. C. E.), elect. engin., telephone engin. (B. S. E. E.), chem. engin. (B. S.), agr. (B. S. Agr.), sci., household econ. (B. S.), phar. (B. S. Phar.), phar. (2 yrs., Ph. C.).	Agr. and hort., animal husb., dairy and creamery, home econ. (winter, 8–10 weeks), farmers' week.
Iowa	Iowa State College of Agriculture and Mechanic Arts.	Ames	A. B. Storms, A. M., D. D., LL. D.	Agron., dairying, animal husb., hort. and forestry, sci. and agr. (B. S. A.), vet. med. (D. V. M.), mech. engin. (B. M. E.), civil engin. (B. C. E.), elect. engin. (B. S. in E. E.), mining engin. (B. S. in Mn. E.), sci., (B. S.), ceramics (B. E. M. in Cer.), dom sci. (B. D. S.).	Mining engin., clay working (2 yrs.), prep. (1 yr.), dairying (1 yr.), dairying (16 weeks), corn and grain judging, stock judging, domestic econ., hort. and forestry (winter, 2 weeks each).
Kansas	Kansas State Agricultural College.	Manhattan	E. R. Nichols, A. M.	Agron., animal husb., dairy, hort., poultry, dom. sci., mech. engin., general sci., elect. engin., civil engin., archi., printing (B. S.), vet. sci. (D. V. M.).	Prep. (1 yr.), domestic sci. (2 terms, 12 weeks each), farmers (2 winter terms, 10 weeks each), summer domestic sci. course for teachers (10 weeks), dairying (2 winter terms, 10 weeks each), agr. for teachers (summer, 6 weeks).

a Including also institutions receiving apportionments from the appropriation of 1890

b Four-year courses unless otherwise specified.

TABLE 1.—*Institutions established under the land-grant act of July 2, 1862, and their courses of study*—Continued.

State or Territory.	Name of institution.	Location.	President.	Collegiate courses of study (undergraduate).	
				Degree courses.	Preparatory and short courses.
Kentucky	State University	Lexington	J. K. Patterson, Ph. D., LL. D.	Clas. (A. B.), mech. engin. (B. M. E.), civil engin. (B. C. E.), mining engin. (B. E. M)., agr. (B. S. Agr.), sci., dom. sci. (B. S.), education (B. S. Edu. and A. B. Edu.), law (2 yrs., LL. B.).	Agr. (2 yrs.), prep. (3 yrs.), rural highway engin. (2 yrs.), mining engin. (2 yrs.), pract. mining (8–10 weeks), agr. (winter, 10 weeks).
	The Kentucky Normal and Industrial Institute for Colored Persons.	Frankfort	J. H. Jackson, A. M.	....	Normal (4 yrs.), normal, agr., carpentry, cooking, music, dressmaking, printing, blacksmithing, wheelwrighting (3 yrs.), business (1 yr.).
Louisiana	Louisiana State University and Agricultural and Mechanical College.	Baton Rouge	T. D. Boyd, A. M., LL. D.	Agr., elect. engin., chem. engin., civil engin., mech. engin., general sci., premed. (B. S.), commerce, Lat. sci., lit., philos. and ed. (B. A.), sugar engin. (5 yrs., B. S.), law (2 yrs., LL. B.), law (3 yrs., B. C. L.).	Agr (2 yrs.).
	Southern University and Agricultural and Mechanical College.	New Orleans	H. A. Hill	....	Sci., agr., high school, printing, girls' indus. (4 yrs.), clas., normal, manual training, grammar, mech. draw., tinsmithing (3 yrs.), bookkeeping, typewriting (2 yrs.), music (5 yrs.).
Maine	University of Maine	Orono	G. E. Fellows, Ph. D., L. H. D., LL. D.	Clas. (B. A.), sci., agron., animal husb., hort., chem., civil engin., mech. engin., elect. engin., chem. engin., mining engin., forestry, phar., el. agr. for teachers (B. S.), law (3 yrs., LL. B.), phar. (2 yrs., Ph. C.).	Agr. (2 yrs.), agr., hort., and dairying (8 weeks), poultry management and hort. (3 weeks), summer school for teachers (5 weeks), farmers' week, reading and correspondence courses in agr.
Maryland	Maryland Agricultural College.	College Park	R. W. Silvester, M. S., LL. D.	Agr., hort., chem., gen. sci., mech. engin., civil engin., elect. engin. (B. S.).	Agr., hort. (2 yrs.), prep. (1 yr.), agr. (winter, 10 weeks), dairying.
	Princess Anne Academy (for colored persons).	Princess Anne	Frank Trigg, A. M	....	Indus., acad., normal (4 yrs.), grammar (2 yrs.).
Massachusetts	Massachusetts Agricultural College.	Amherst	K. L. Butterfield, A. M.	Agr. (B. S.)	Dairy farm. (winter, 10 weeks), bee culture (2 weeks), summer school of agr. for teachers, et al. (2, 4, and 6 weeks).
	*Massachusetts Institute of Technology.	Boston	R. C. Maclaurin, M. A., LL. D.	Civil engin., mech. engin., mining engin. and metal., archi., chem., elect. engin., biol., phys., electro-chem., chem. engin., sanitary engin., geol. and geodesy, naval archi., general sci. (B. S.).	
Michigan	Michigan State Agricultural College.	East Lansing	J. L. Snyder, A. M., Ph. D.	Agr., engin., forestry, women's (B. S., each 4 and 5 yrs.).	Prep. (1 yr.), cheese making (4 weeks), creamery management (6 weeks), live stock and general farming, fruit culture (8 weeks), summer school of agr. for teachers (4 weeks), farmers' reading course.

Minnesota	The University of Minnesota.	Minneapolis	Cyrus Northrop, LL. D.	General (B. A.), civil engin. (C. E.), mech. engin. (M. E.), elect. engin. (E. E.), mining, metal. (E. M., Met. E.), chem. (A. C. or C. T.), agr. (B. S. Agr.), forestry (B. S. For.), home econ. (B. S.).	Agr. (3 yrs.), home econ. (3 yrs.), agr. (8 weeks), forestry (summer, 6 weeks), dairying (4 weeks), traction engin. (4 weeks), el. agr. for teachers (summer, 3 weeks).
Mississippi	Mississippi Agricultural and Mechanical College.	Agricultural College.	J. C. Hardy, A. M., LL. D.	Agr., mech. engin., elect. engin., civil and mining engin., textile indus., pedagogy (B. S.).	Agr., mech. arts, elect. engin., textile (2 yrs.), prep. (1 yr.), pract. working boys' course (1 yr.), agr. (10 weeks), summer normal school for teachers (4 weeks).
	Alcorn Agricultural and Mechanical College.	Alcorn	L. J. Rowan, B. S.	Scientific (B. S.)	Business, carp., agr., shoemak., blacksm., paint., dom. sci., millinery, etc. (3 yrs.), prep. (2 yrs.), primary (3 yrs.).
Missouri	University of Missouri	Columbia	A. R. Hill, Ph. D	Gen. Sci. (B. A.), agr., home econ. (B. S.), civil engin. (B. S., C. E.), mech. engin., min. engin. (B. S., M. E.), elect. engin. (B. S., E. E.), san. engin., chem. engin., hydraulic engin., mining, metal. (B. S.), med. (3 yrs., M. D.), law (3 yrs., LL. B.).	Plant production, animal husb., dairying (8 weeks), summer school for teachers (8 weeks).
	Lincoln Institute	Jefferson	B. F. Allen, A. M., LL. D.	Collegiate (B. A)	Normal (4 yrs.), college prep., normal (2 yrs.), normal prep., carpentry, blacksmithing, mach. work, sewing, cooking, laundering (3 yrs.), summer school (7 weeks).
Montana	Montana Agricultural College.	Bozeman	J. M. Hamilton, M. S.	General sci., domestic sci., phar. (B. S.), agron., animal husb., dairying, hort. and forestry (B. S. A.), mech. engin. (B. M. E.), elect. engin. (B. E. E.), civil engin. (B. C. E.), phar. (2 yrs., Ph. C.).	Art (4 yrs.), agr. (3 yrs.), prep. (4 yrs.), domestic sci. (1 yr.), creamery (4 weeks), agr. and dairying (10 days), music.
Nebraska	University of Nebraska	Lincoln	E. B. Andrews, LL. D.	Clas., lit. (B. A.), general sci., agr., home econ., civil engin., elect. engin., steam engin., municipal engin., mech. engin., premed., tech. forestry, phar. (B. S.), teachers' course (B. A. and B. S.), med. (M. D.), law (3 yrs., LL. B.), phar. (3 yrs., Ph. C., 2 yrs., Ph. G.).	El. agr. (3 yrs.), mech. arts (2 yrs.), agr. (1 yr.), teachers' courses in agr., home econ., and manual training (1 yr. each), dairying, agr. (9 weeks), summer session (6 weeks), judging (1 week), art, music, corresp. course in nature study for teachers.
Nevada	University of Nevada	Reno	J. E. Stubbs, M. A., D. D., LL. D.	Liberal arts (B. A.), mining engin., agr., domestic sci., mech. engin., civil engin., general sci. (B. S.).	Agr., Lat., sci., coml. (high school, 3 yrs.), agr., dairying, bot., ent., bact., domestic sci., assaying (3 months).
New Hampshire	The New Hampshire College of Agriculture and Mechanic Arts.	Durham	W. D. Gibbs, D. Sc.	Agr., mech. engin., elect. engin., chem. engin., general (B. S.).	Agr. (2 yrs.), agr. (winter, 10 weeks), dairying (winter, 10 weeks).
New Jersey	Rutgers Scientific School, The New Jersey State College for the Benefit of Agriculture and Mechanic Arts.	New Brunswick.	W. H. S. Demarest, A. M., D. D.	General sci., agr., civil engin., mech. engin., chem., elect., biol., clay working and ceramics (B. S.), Lat. sci. (B. Litt.).	Clay working and ceramics (2 yrs.), general agr., dairy farming, fruit growing, and market gardening (12 weeks each).
New Mexico	New Mexico College of Agriculture and Mechanic Arts.	Agricultural College.	W. E. Garrison, Ph.D.	Agr., mech. engin., civil engin., elect. engin., domestic sci., general or sci. (B. S.).	Agr. and hort. (2 yrs.), pract. mech. (2 yrs.), prep. (4 yrs.), Engl. and Span. sten. (1 yr. each), commerce (2 yrs.), agr. and household econ. (2 yrs. of 4 winter months each).

TABLE 1.—*Institutions established under the land-grant act of July 2, 1862, and their courses of study*—Continued.

State or Territory.	Name of institution.	Location.	President.	Collegiate courses of study (undergraduate). Degree courses.	Collegiate courses of study (undergraduate). Preparatory and short courses.
New York	Cornell University	Ithaca	J. G. Schurman, A.M., D. Sc., LL. D.	Arts (A. B.), civil engin. (C. E.), mech. engin. (M. E.), elect. engin. (E. E.), archi. (B. Arch.), agr. (B. S. A.), vet. med. (3 yrs., D. V. M.), law (3 yrs., LL. B.).	Special lect. courses in general agr. and nature study (1 or 2 yrs.), poultry husb. (1 yr.), agr., dairying, poultry husb., hort., home econ. (winter, 11 weeks), reading courses for farmers and farmers' wives, summer school for teachers, nature study correspondence course for teachers.
North Carolina	The North Carolina College of Agriculture and Mechanic Arts.	West Raleigh	D. H. Hill, A. M., Litt. D.	Agr. (B. Agr.), mech. engin., civil engin., elect. engin., mining engin., textile sci., and art (B. E.), indus. chem., dyeing (B. S.).	Mech. arts, textile art (2 yrs.), normal courses in agr. and nature study (1 and 2 yrs.), agr. (1 yr.), agr. and dairying, textile art (10 weeks), May school for agr. teachers (1 month).
	The Agricultural and Mechanical College for the Colored Race.	Greensboro	J. B. Dudley, A. M., LL. D.	Agr. (B. Agr.), mech. (B. S.)	Prep. (4 yrs.), dairying (6 weeks).
North Dakota	North Dakota Agricultural College.	Agricultural College.	J. H. Worst, LL. D.	Agr., gen. sci., mech. engin., civil engin., pharm., chem. (B. S.).	Farm husb. (3 yrs.), steam engin., dairying, phar., domestic econ., prep. (2 yrs.), nature study, el. agr. and mech. arts for teachers (3 yrs.), agr., steam engin., domestic econ. (winter, 12 weeks each), corresp. course in el. agr.
Ohio	Ohio State University	Columbus	W. O. Thompson, A. M., D. D., LL. D.	Agr. (B. S. Agr.), hort. and forestry, dom. sci., chem., indus. arts, manual training, phar. (B. S.), arts, philos. and sci., ed. (B. A.), archi., civil engin. (C. E.), clay working and ceramics (Cer. E.), mining engin. (E. M.), elect. engin. (M. E. in E. E.), mech. engin. (M. E.), vet. med. (3 yrs., D. V. M.), aw (3 yrs., LL. B.).	Agr., hort., ceramics, indus. arts, mining, phar. (2 yrs.), agr. (10 weeks), agr. for teachers (summer, 6–8 weeks), winter dairy school.
Oklahoma	Oklahoma Agricultural and Mechanical College.	Stillwater	J. H. Connell, M. S.	Agr., general sci., mech. engin., civil engin., elect. engin., sci. and lit. (5 yrs., B. S.).	Agr. and dom. sci. (2 yrs.), business, agr. (1 yr.), agr. and dairy (winter, 10 weeks), cotton grading (3 weeks), stock judging and seed selection (1 week), summer normal for teachers of agr. (6 weeks), corresp. course in agr. for teachers (2 yrs.).
	Agricultural and Normal University.	Langston	I. E. Page, M. A.	Clas. (B. A.), sci. (B. S.), normal (B. S. D.), agr. (B. S. Agr.), elect. engin., mech. engin., civil archi. (B. M. E.).	Normal elementary (4 yrs.), college prep. (3 yrs.).
Oregon	Oregon State Agricultural College.	Corvallis	W. J. Kerr, D. Sc.	Agron., mech. engin., elect. engin., civil engin., mining engin., dom. sci. and art, phar., commerce, hort., forestry, animal husb., dairy husb., poultry husb. (B. S.),	Mining, phar. (2 yrs.), el. agr., mech. arts, dom. sci. and art, forestry, commerce (2 yrs.), dairying (2 and 6 weeks), gen. agr. (4 weeks), hort. (6 weeks), farmers' week, el. agr. summer school for teachers.

Pennsylvania	The Pennsylvania State College.	State College	E. E. Sparks, Ph. D.	Clas. (B. A.), mod. lang. and lit., general sci., (B. Litt.), Lat. sci., philos., agr'l chem., agron., animal husb., hort., forestry, home econ., biol., chem., civil engin., elect. engin., electrochem. engin., indus. chem., math., mech. engin., mines and metal, plant path., phys., sanitary engin. (B. S.).	Agr., mech., mining (2 yrs.), prep. (1 yr.), agr., hort., dairy husb. and manf., poultry husb., mining (12 weeks), summer school (2 weeks), 31 corresp. courses in agr., farmers' week.
Porto Rico	University of Porto Rico.	San Juan	E. G. Dexter, A. M., Ph. D.	....	Agr. (3 yrs.), normal (2 and 3 yrs.).
Rhode Island	Rhode Island College of Agriculture and Mechanic Arts.	Kingston	Howard Edwards, M. A., LL. D.	Agr., mech. engin., civil engin., chem. engin., elect. engin., teachers' course in applied sci., and home econ. (B. S.).	Agr. (2 yrs.), engin. (2 yrs.), prep. (2 yrs.), poultry school (winter, 12 weeks).
South Carolina	The Clemson Agricultural College of South Carolina.	Clemson College.	P. H. Mell, Ph. D., LL. D.	Agr., agr. and chem., agr. and animal husb., mech. and elect. engin., civil engin., chem. and geol., textile indus. (B. S.).	Textile indus. (2 yrs.), prep. (1 yr.), cotton grading (6 weeks).
	The Colored Normal, Industrial, Agricultural, and Mechanical College of South Carolina.	Orangeburg	T. E. Miller, LL. D.	Regular (B. A.), mech. (B. S.), agr. (B. Agr.).	Prep. and normal (5 yrs.), model school, indus., music, art.
South Dakota	South Dakota State College of Agriculture and Mechanic Arts.	Brookings	R. L. Slagle, A. M., Ph. D.	Agr., domestic sci., general sci., mech. engin., elect. engin., civil engin. (B. S.), phar. (2 yrs., Ph. G.).	Prep., coml. sci. (3 yrs.), dairying (1 yr.), agr. (6 weeks), hort., domestic sci., butter making and cheese making, steam engin. (12 weeks), commercial sci., steam engin. (1 yr.), poultry husb., dairy sci. (winter, 2 weeks), music.
Tennessee	University of Tennessee.	Knoxville	Brown Ayres, Ph. D., LL. D., D. C. L.	Lit. (B. A.), agr., home econ., sci., civil engin., mech. engin., elect. engin., mining engin., metal., chem. engin., phar. chem. (B. S.), med. (M. D.), education (B. A. and B. S. in Ed.), dental surgery (3 yrs., D. D. S.), phar. chem. (2 yrs., Ph. C.), law (2 yrs., LL. B.).	El. agr. for negroes (4 yrs.), prep. med. (2 yrs.), agron., animal husb., dairy husb., poultry husb., bee keeping, home econ., hort. (2 weeks each), summer school for teachers (6 weeks).
Texas	Agricultural and Mechanical College of Texas.	College Station	R. T. Milner	Agr., hort., animal husb., textile engin., elect. engin., mech. engin., civil engin., archi. engin. (B. S.).	Agr. (2 yrs.).
	Prairie View State Normal and Industrial College.	Prairie View	E. L. Blackshear	....	Normal and indus. (4 yrs.), agr. and hort. (2 yrs.), dairying (2 yrs.).
Utah	Agricultural College of Utah.	Logan	J. A. Widtsoe, A. M., Ph. D.	Agron., hort. and ent., animal husb. and dairying, irrig. and drainage, vet. sci., forestry, domestic sci., commerce, general sci. (B. S.).	Manual training in mech. arts (4 yrs.), manual training in agr. and domestic sci. (3 yrs each), commerce (3 yrs.), prep. (2 yrs.), general sci. (2 yrs.), dairying (1 yr.), agr. (3 weeks), domestic sci. and arts, mech. arts, forestry (12 weeks), commerce (14 weeks), dairying (2 weeks), summer school (5 weeks), music.
Vermont	University of Vermont and State Agricultural College.	Burlington	M. H. Buckham, D. D., LL. D.	Clas. (B. A.), lit. sci. (Ph. B.), civil and sanitary engin., elect. engin., mech. engin., chem., agr., commerce and econ. (B. S.), med. (M. D.).	Agr. (2 yrs.), dairying (8 weeks).

TABLE 1.—*Institutions established under the land-grant act of July 2, 1862, and their courses of study*—Continued.

State or Territory.	Name of institution.	Location.	President.	Collegiate courses of study (undergraduate). Degree courses.	Collegiate courses of study (undergraduate). Preparatory and short courses.
Virginia	The Virginia Agricultural and Mechanical College and Polytechnic Institute.	Blacksburg	P. B. Barringer, M. D., LL. D.	Agr., hort., applied chem., general sci., civil engin., mech. engin., elect. engin., mining engin., metal. and metallography, applied geol., prep. med. and vet. sci. (B. S.).	Agr. apprentice course (2 yrs.), farmers' winter course (1 month).
	The Hampton Normal and Agricultural Institute.	Hampton	H. B. Frissell, D. D., LL. D.	....	Academic (4 yrs.), trade (3 yrs.), pract. agr. (3 yrs.). Graduate: Agr. (3 yrs.), dom. sci. and art (2 yrs.), matrons' course (1 or 2 yrs.), normal (2 yrs.), business (1 yr.), library methods.
Washington	State College of Washington.	Pullman	E. A. Bryan, A. M., LL. D.	Math. and civil engin., domestic econ., phar., chem., bot., zool., agron., animal husb., dairying, hort., vet. sci., econ. sci. and hist., elect. engin., mech. engin., mining engin. (B. S., B. A.), geol., Engl. lang. and lit., modern lang., Latin, education, archi. (B. A.), vet. sci. (3 yrs., D. V. S.), phar. (2 yrs., Ph. G.), music (3 yrs., B. Mus.).	Forestry (3 yrs.), artisans (1 yr.), bookkeeping, sten. (2 yrs. each), agr. (20 weeks), assaying (12 weeks), dairying (8 weeks), summer science school for teachers (6 weeks).
West Virginia	West Virginia University.	Morgantown	D. B. Purinton, Ph. D., LL. D.	General culture (B. A., B. S.), mech. and elect. engin. (B. S. M. E. and B. S. E. E.), civil engin. (B. S. C. E.), mining engin. (B. S. E. M.), agr. (B. S. Agr.), law (LL. B.). med. (B. S.), vet. sci. (3 yrs., D. V. S.).	Sec. agr. (3 yrs., diploma), agr., mech. and elect., law, commercial (2 yrs.), agr., prep. (1 yr.), agr., hort., animal husb., dairying, poultry culture (12 weeks), el. agr. and nature study (summer, 6 weeks), agr. (winter, 4 weeks), music.
	The West Virginia Colored Institute.	Institute	J. McH. Jones, A. M.	....	Normal (4 yrs.), agr. (4 yrs.), acad. (3 yrs.), sewing (2 yrs.), dressmaking (2 yrs.), commercial (2 yrs.), mech., printing (3 yrs.).
Wisconsin	University of Wisconsin.	Madison	C. R. Van Hise, Ph. D., LL. D.	Sci., home econ., commerce (B. A.), normal (B. Ph.), agr. (B. S. Agr.), civil engin., sanitary engin., mech. engin., elect. engin., general engin., applied electrochem., phar. (B. S.), law (3 yrs. prof., LL. B.), phar. (2 yrs., Ph. G.).	Agr. (2 winter courses, 14 weeks each), dairy school (winter, 12 weeks), creamery (summer), farmers' course (2 weeks), summer school (6 weeks), music.
Wyoming	University of Wyoming.	Laramie	C. O. Merica, A. M., LL. D.	Clas., lit., sci., education (B. A.), normal (B. Ped.), polit. sci., hist., general sci., agr., mech. engin., mining engin., irrig. engin. (B. S.).	Prep. (3 yrs.), agr. (1 to 2 yrs.), agr. (12 weeks), school of mines (6 weeks), animal husb. (winter), domestic sci., irrig., livestock management and judging (2 weeks), music, commerce, corresp. courses.

TABLE 2.—*General statistics of*

	State or Territory.	Date of establishment of institution.	Date of establishment of agricultural course.	Faculty.				
				College of agriculture and mechanic arts.			Other departments.	Experiment station officers.
				Preparatory classes (*a*).	Collegiate and special courses.	Total.		
1	Alabama (Auburn)	1872	1872	4	50	54	....	19
2	Alabama (Normal)	1875	1882	5	21	26	4	....
3	Arizona	1891	1891	11	15	26	....	12
4	Arkansas (Fayetteville)	1872	1872	11	49	60	56	13
5	Arkansas (Pine Bluff)	1875	....	8	2	10	....	....
6	California	1868	1868	....	82	82	192	57
7	Colorado	1877	1878	9	49	58	....	24
8	Connecticut	1881	1881	....	21	21	....	12
9	Delaware (Newark)	1870	1870	....	19	19	3	9
10	Delaware (Dover)	1892	1892	6	6	*c*7	....	....
11	Florida (Gainesville)	1884	1884	3	10	*c*10	6	15
12	Florida (Tallahassee)	1887	1890	23	....	23	....	....
13	Georgia (Athens)	1872	1872	....	35	35	....	....
14	Georgia (Savannah)	1890	1890	12	4	16	....	....
15	Hawaii	1907	1907	2	2	*c*2	....	....
16	Idaho	1892	1892	7	21	*c*27	12	9
17	Illinois	1867	1868	13	111	124	361	47
18	Indiana	1874	1874	....	139	139	....	31
19	Iowa	1869	1869	....	144	144	20	27
20	Kansas	1863	1874	7	92	99	13	33
21	Kentucky (Lexington)	1865	1880	5	47	52	....	23
22	Kentucky (Frankfort)	1887	1892	5	8	13	....	....
23	Louisiana (Baton Rouge)	1877	1887	11	35	*c*38	4	29
24	Louisiana (New Orleans)	1880	1890	10	8	18	....	....
25	Maine	1865	1868	6	61	*c*61	10	18
26	Maryland (College Park)	1859	1859	2	23	*c*23	....	20
27	Maryland (Princess Anne)	....	....	12	....	12	....	....
28	Massachusetts (Amherst)	1867	1867	....	41	41	....	28
29	Massachusetts (Boston)	1865	....	....	253	253	....	....
30	Michigan	1855	1855	....	93	93	....	26
31	Minnesota	1869	1869	48	45	93	137	28
32	Mississippi (Agricultural College)	1880	1880	7	37	44	....	16
33	Mississippi (Alcorn)	1871	1878	7	5	12	10	....
34	Missouri (Columbia)	1870	1870	....	54	54	176	37
35	Missouri (Jefferson City)	1866	1866	2	21	23	....	....
36	Montana	1893	1893	15	31	*c*33	....	14
37	Nebraska	1869	1869	41	15	56	112	26
38	Nevada	1873	1888	13	28	*c*34	....	12
39	New Hampshire	1866	1886	....	31	31	....	14
40	New Jersey	1864	1865	12	31	*c*42	4	10
41	New Mexico	1889	1890	3	28	31	....	18
42	New York	1865	1865	....	134	134	414	33
43	North Carolina (West Raleigh)	1889	1889	....	42	42	....	17
44	North Carolina (Greensboro)	1891	1891	2	12	14	....	....
45	North Dakota	1890	1890	51	33	*c*59	....	27
46	Ohio	1870	1873	....	130	130	53	....
47	Oklahoma (Stillwater)	1891	1892	....	34	34	....	10
48	Oklahoma (Langston)	1897	1899	3	6	9	8	....
49	Oregon	1868	1888	49	49	*c*49	4	24
50	Pennsylvania	1855	1859	14	99	113	....	34
51	Porto Rico	1903	1904	5	....	5	15	....
52	Rhode Island	1888	1890	9	23	*c*24	....	15
53	South Carolina (Clemson College)	1889	1893	2	44	46	....	11
54	South Carolina (Orangeburg)	1896	1896	8	6	14	8	....
55	South Dakota	1881	1884	3	39	42	....	16
56	Tennessee	1794	1869	....	49	49	39	21
57	Texas (College Station)	1871	1871	....	48	48	....	16
58	Texas (Prairie View)	....	....	8	7	15	....	....
59	Utah	1888	1889	12	14	26	27	18
60	Vermont	1865	1885	....	43	43	37	16
61	Virginia (Blacksburg)	1872	1872	....	56	56	....	19
62	Virginia (Hampton)	1868	1890	122	....	122	....	....
63	Washington	1892	1892	75	97	*c*97	....	18
64	West Virginia (Morgantown)	1867	1867	....	17	17	55	14
65	West Virginia (Institute)	1891	1892	6	16	22	....	....
66	Wisconsin	1848	1866	....	90	90	270	47
67	Wyoming	1887	1891	....	23	23	....	12
	Total	....	....	689	2,878	3,362	2,050	995

a Including schools of agriculture of high-school grade under the control of the institution.

land-grant colleges, 1908.

Graduates. In 1907-8. Number.	Graduates. In 1907-8. Average age.	Graduates. Total number since organization.	Library. Number of volumes.	Library. Number of pamphlets.	Number of acres allotted to State under act of 1862.	Number of acres of land grant of 1862 still unsold.	Number of acres in farm and grounds.	Rate of interest on land-grant fund of 1862.	
	Y. M.							*Per cent.*	
84	21	1,053	22,620	2,800	240,000	....	325	8	1
77	19	1,316	392	1,400	....	....	182	....	2
5	25	60	12,000	13,000	....	....	465	....	3
75	24	585	10,000	4,000	150,000	....	160	8	4
6	20	197	3,200	....	....	....	20	....	5
431	23	b 5,318	210,000	50,000	150,000	1,402	1,045	6	6
23	....	331	30,000	80,000	90,000	40,000	1,818	6	7
18	21 8	284	10,970	1,000	180,000	....	656	5	8
17	22	427	16,500	9,000	90,000	....	227	6	9
17	20	64	800	500	....	....	97	....	10
7	20	118	7,500	2,500	90,000	....	527	6	11
8	22	116	788	....	....	....	200	....	12
23	21	460	30,000	....	270,000	....	900	7	13
12	24	188	700	400	....	....	86	....	14
....	....	....	6,000	2,000	....	....	41	....	15
26	23 9	215	12,696	2,400	90,000	85,000	225	....	16
359	23 6	b 5,308	110,390	13,016	480,000	40	715	5	17
305	23 11	3,020	20,000	5,000	390,000	....	241	5	18
166	....	....	24,600	5,500	294,000	....	1,175	6, 7, 8	19
113	22 8	1,442	33,300	800	82,313	....	430	5, 5½, 6, 7	20
79	21	687	7,114	16,928	330,000	....	298	6	21
19	23	188	1,300	1,730	....	....	310	....	22
35	21 8	494	27,000	....	210,000	....	664	4, 5	23
33	18	418	2,633	1,750	....	....	104	....	24
70	24	1,234	36,500	10,000	210,000	....	373	5	25
28	20	....	7,000	7,500	210,000	....	286	5, 6	26
24	19	86	2,000	600	....	....	118	....	27
58	....	771	28,868	....	360,000	....	403	5	28
229	23	3,862	78,161	21,814	....	....	18	....	29
84	23 8	1,355	29,458	6,003	235,673	49,938	684	7	30
500	....	b 7,049	112,000	....	94,000	40	470	3, 4, 5	31
58	20 6	520	12,983	11,919	207,920	....	2,000	6	32
117	21	304	2,700	....	....	....	300	....	33
326	24 6	3,057	88,063	20,000	277,016	47,607	722	5	34
39	19	444	3,000	2,000	....	....	28	....	35
10	22	78	9,300	6,000	90,000	86,533	220	....	36
294	22	b 3,186	89,650	9,000	90,000	9,000	332	4½, 6	37
33	....	364	14,987	15,360	90,000	2,200	85	4	38
30	22 6	346	23,563	4,500	150,000	....	345	6	39
34	22 8	670	57,025	5,000	210,000	....	142	5	40
20	22	90	11,000	120	....	....	458	....	41
649	23	b 10,018	353,638	53,000	989,920	....	990	5	42
48	21 10	404	5,324	1,700	270,000	....	685	6	43
18	20	85	1,494	16,000	....	....	128	....	44
12	25 5	68	20,068	800	130,000	60,685	640	....	45
282	23	2,672	78,264	2,500	630,000	....	439	6	46
23	23 2	184	12,375	30,000	250,000	250,000	1,000	....	47
4	25	....	375	....	....	....	160	....	48
80	21	737	5,000	....	90,000	4,200	224	6	49
128	22	1,164	33,000	....	780,000	....	400	6	50
....	....	....	2,378	1,200	....	....	148	....	51
12	24	137	16,413	5,000	120,000	....	178	3	52
85	....	550	28,837	4,200	180,000	....	1,136	6	53
44	20	463	1,000	900	....	....	130	....	54
28	23	361	10,560	10,914	160,000	156,202	560	....	55
59	22 8	....	27,546	18,000	300,000	....	272	6	56
49	22	677	6,212	7,570	180,000	....	2,416	6, 7	57
71	20	590	2,000	....	....	....	1,490	....	58
12	26	154	15,920	16,157	200,000	47,218	116	....	59
50	23	3,998	76,412	33,404	150,000	....	146	6	60
43	21	771	9,743	13,332	300,000	....	408	6	61
65	....	1,507	23,898	....	....	....	760	....	62
76	23 5	332	16,897	11,000	90,000	80,062	466	....	63
53	22	1,165	27,100	300	150,000	....	130	6	64
23	20	188	3,025	1,750	....	....	70	....	65
467	23	b 6,659	135,000	36,000	240,000	312	500	4	66
9	21	160	25,000	12,000	90,000	90,000	416	....	67
6,282	22 1	78,749	2,144,180	609,267	10,570,842	1,010,439	31,903	....	

b Including all departments of the university.

c Total, counting none twice.

TABLE 3.—*Students, by classes and*

PART 1.—WHITE

	State or Territory.	By classes.						By courses.	
								Four-year.	
		Preparatory.[a]	Collegiate.	Short or special.[b]	Post graduate.	Other departments.	Total.	Agriculture.	Horticulture.
1	Alabama	72	527	....	18	....	617	42	20
2	Arizona	167	64	....	6	....	237	....	......
3	Arkansas	550	582	45	....	470	1,647	53	23
4	California	....	959	....	85	2,232	[d] 3,276	132	......
5	Colorado	84	228	162	3	....	477	31	12
6	Connecticut	....	137	124	....	....	[d] 257	59	9
7	Delaware	4	123	41	1	21	190	2	......
8	Florida	20	51	3	3	26	103	2	......
9	Georgia	....	252	427	4	....	683	27	......
10	Hawaii	5	....	50	....	....	55	....	......
11	Idaho	174	133	21	....	117	445	4	......
12	Illinois	377	1,663	555	74	2,066	[d] 4,368	437	......
13	Indiana	....	1,642	204	61	....	1,907	[f] 103	......
14	Iowa	232	1,421	660	14	56	2,383	330	[g] 44
15	Kansas	662	1,109	387	26	....	[d] 2,192	215	......
16	Kentucky	115	465	273	29	182	1,064	18	......
17	Louisiana	141	399	....	5	91	636	25	......
18	Maine	17	549	140	21	97	[d] 776	18	......
19	Maryland	35	176	41	4	....	[d] 240	16	12
20	Massachusetts	....	245	248	7	....	500	245	......
21	Massachusetts (Boston)	....	1,390	283	20	....	[d] 1,410	....	......
22	Michigan	193	761	206	6	....	[d] 1,191	275	......
23	Minnesota	808	589	90	107	2,911	4,505	116	......
24	Mississippi	326	651	386	5	....	1,368	191	......
25	Missouri	....	448	109	13	2,424	2,994	164	......
26	Montana	121	164	130	4	....	419	16	......
27	Nebraska	298	704	202	105	1,928	3,237	42	3
28	Nevada	161	185	....	1	....	347	1	......
29	New Hampshire	....	181	22	....	....	203	50	......
30	New Jersey	135	191	42	3	61	432	5	......
31	New Mexico	185	106	5	25	....	321	12	......
32	New York	....	1,475	270	....	2,728	[d] 4,465	348	......
33	North Carolina	....	351	104	15	....	470	60	......
34	North Dakota	329	126	525	6	....	986	28	......
35	Ohio	....	1,185	319	5	1,385	[d] 2,686	107	[g] 17
36	Oklahoma	237	283	[j] 544	....	....	1,064	34	......
37	Oregon	141	808	173	15	20	[d] 1,156	100	......
38	Pennsylvania	81	951	[j] 5,164	5	....	6,201	62	4
39	Porto Rico	39	....	....	....	159	198	....	......
40	Rhode Island	36	98	19	3	....	153	18	......
41	South Carolina	82	591	16	1	....	690	261	......
42	South Dakota	168	180	169	8	....	525	19	2
43	Tennessee	....	346	185	5	220	[d] 755	22	......
44	Texas	....	592	27	4	....	623	[f] 84	......
45	Utah	211	106	355	2	208	882	74	......
46	Vermont	....	344	30	1	152	[d] 527	34	......
47	Virginia	40	492	21	14	....	567	54	5
48	Washington	375	793	143	25	....	1,336	84	38
49	West Virginia	....	105	50	....	1,053	1,208	7	......
50	Wisconsin	....	1,052	623	29	2,337	[d] 4,013	146	......
51	Wyoming	63	24	....	....	137	224	3	......
	Total	6,684	25,997	13,593	788	21,081	67,209	4,176	189

[a] Including schools of agriculture of high-school grade under the control of the institution.
[b] Including summer school.
[c] Three-year and less.
[d] Total, counting none twice.
[e] Under "collegiate" in distribution "by classes."

courses, at land-grant colleges, in 1908.

STUDENTS.

By courses.														
Four-year.				Shorter.										
											Teachers' courses in agriculture.			
Forestry.	Veterinary science.	Household economy.	Engineering.	Mechanic arts.	Agriculture. a	Horticulture.	Forestry.	Dairying.	Veterinary science. c	Household economy.	Two-year.	Summer school.	Military tactics.	
......	19	......	262	......	......	......	......	......	......	......	......	......	559	1
......	......	......	22	......	......	......	......	......	......	......	......	......	77	2
......	12	......	227	33	33	31	......	28	17	......	......	......	615	3
......	......	......	878	......	......	......	......	......	......	......	......	......	973	4
......	......	7	108	......	91	......	27	......	e 29	36	......	......	226	5
......	......	14	14	10	34	......	......	11	......	13	......	94	102	6
......	......	......	121	......	31	......	......	......	......	......	4	......	150	7
......	......	......	31	......	3	......	......	......	......	......	......	......	85	8
......	......	......	186	......	105	......	......	......	......	......	......	......	350	9
......	......	......	......	......	......	......	......	......	......	......	......	......	......	10
......	......	6	121	103	21	1	......	6	......	51	......	......	161	11
......	......	102	1,224	......	......	......	......	......	......	......	......	......	1,329	12
5	......	10	1,779	......	115	35	......	19	......	3	......	......	841	13
......	108	164	838	24	542	......	......	81	......	37	......	......	339	14
......	55	320	438	......	173	134	......	26	......	188	......	......	573	15
......	......	20	314	38	22	......	......	......	......	......	......	......	299	16
......	......	......	183	......	19	......	......	......	......	......	......	......	394	17
39	......	......	324	......	29	......	......	......	......	......	......	......	......	18
......	......	......	93	......	41	......	......	......	......	......	......	......	180	19
......	......	......	......	......	h 10	......	......	32	......	......	......	210	175	20
......	......	......	1,261	......	......	......	......	......	......	......	......	......	......	21
26	......	199	485	......	119	19	......	68	......	......	......	......	582	22
......	......	......	633	......	715	......	......	93	......	......	......	90	1,026	23
......	......	......	338	7	10	......	......	6	......	......	......	363	931	24
......	......	55	598	......	109	......	......	......	......	......	......	......	367	25
......	......	31	72	18	29	......	......	36	......	15	......	......	......	26
29	......	20	438	9	493	......	......	......	......	......	......	......	573	27
......	......	115	99	......	......	......	......	......	......	......	......	......	121	28
......	......	......	82	......	15	......	......	7	......	......	......	......	154	29
......	......	......	77	......	42	......	......	......	......	......	......	......	177	30
......	......	5	26	29	1	......	......	......	......	3	......	......	166	31
......	......	......	1,692	23	270	......	......	......	e 82	......	......	......	450	32
......	......	......	293	24	21	......	......	15	......	......	......	13	400	33
......	......	......	47	303	152	......	......	......	......	39	i 35	......	222	34
......	......	71	749	17	261	......	......	14	e 162	16	......	......	942	35
......	......	......	112	......	432	......	......	......	......	......	a 135	......	......	36
10	......	108	345	12	88	12	......	28	......	47	......	......	733	37
22	......	11	724	......	114	......	......	......	......	7	......	......	866	38
......	......	......	......	......	39	......	......	......	......	......	......	......	......	39
......	......	2	51	11	26	......	......	......	......	......	......	......	83	40
......	......	......	331	......	1	......	......	......	......	......	......	......	674	41
......	......	21	74	83	62	......	......	10	......	28	......	......	209	42
......	......	36	141	......	114	......	......	......	......	......	......	68	162	43
......	......	......	388	......	27	......	......	......	......	......	......	......	623	44
......	......	17	15	117	110	......	49	......	......	83	......	......	206	45
......	......	......	119	......	......	......	......	30	......	......	......	......	166	46
......	8	......	382	2	6	......	......	......	......	......	......	......	490	47
......	5	85	511	42	65	40	21	16	......	......	......	206	516	48
......	......	......	98	......	12	......	......	39	8	......	......	......	225	49
......	......	54	1,077	......	390	......	......	144	......	......	......	......	627	50
......	......	......	16	......	5	......	......	......	......	......	......	......	80	51
131	207	1,473	18,437	905	4,997	272	97	709	298	566	174	1,044	19,199	

f Including horticulture.
g Including forestry.
h Bee-keeping.
i Three-year course.
j Including correspondence courses.

TABLE 3.—*Students, by classes and courses,*

PART 2.—NEGRO

	State or Territory.	By classes.					By courses.		
		Preparatory.	Collegiate.	Short or special.	Other departments.	Total.	Agriculture.	Carpentry.	Machine-shop work.
1	Alabama (Normal)	80	3	48	136	267	74	20	15
2	Arkansas (Pine Bluff)	310	21	......	38	369	......	74	16
3	Delaware (Dover)	62	48	......	8	118	25	30	15
4	Florida (Tallahassee)	307	......	......	......	307	75	14	......
5	Georgia (Savannah)	281	12	......	......	293	2	22	......
6	Kentucky (Frankfort)	132	111	......	38	281	24	28	......
7	Louisiana (New Orleans)	394	......	......	......	394	37	60	......
8	Maryland (Princess Anne)	149	......	......	......	149	106	17	......
9	Mississippi (Alcorn)	439	103	......	......	542	73	75	......
10	Missouri (Jefferson City)	101	3	85	346	535	63	75	58
11	North Carolina (Greensboro)	80	114	103	......	297	197	48	12
12	Oklahoma (Langston)	301	73	31	......	405	143	28	8
13	South Carolina (Orangeburg)	620	59	3	7	689	20	34	34
14	Texas (Prairie View)	260	208	......	......	468	98	40	......
15	Virginia (Hampton)	1,172	......	......	215	1,387	1,387	63	13
16	West Virginia (Institute)	73	110	42	9	[b] 237	12	13	......
	Total	4,761	865	312	797	6,738	2,336	641	171

[a] Including plastering.

TABLE 4.—*Value of permanent funds and*

	State or Territory.	Land-grant fund of 1862.	Other land-grant funds.	Other permanent funds.	Land grant of 1862 still unsold.	Farms and grounds owned by the institution.
1	Alabama (Auburn)	$253,500.00	....	....	....	$9,000.00
2	Alabama (Normal)	....	....	....	....	10,000.00
3	Arizona	....	....	$10,000.00	....	29,140.00
4	Arkansas (Fayetteville)	130,000.00	....	....	....	15,000.00
5	Arkansas (Pine Bluff)	....	....	....	....	60,000.00
6	California	732,233.14	$154,712.27	3,214,548.61	$11,818.27	185,467.23
7	Colorado	128,465.28	....	....	125,000.00	225,000.00
8	Connecticut	135,000.00	....	61,000.00	....	25,000.00
9	Delaware (Newark)	83,000.00	....	....	....	45,000.00
10	Delaware (Dover)	....	....	....	....	6,000.00
11	Florida (Gainesville)	153,800.00	40,000.00	....	....	50,000.00
12	Florida (Tallahassee)	....	....	....	....	20,000.00
13	Georgia (Athens)	242,202.17	....	....	....	200,000.00
14	Georgia (Savannah)	....	....	....	....	6,776.25
15	Hawaii	....	....	....	....	60,000.00
16	Idaho	15,717.12	372,982.54	....	850,000.00	45,000.00
17	Illinois	647,477.53	....	....	400.00	410,000.00
18	Indiana	340,000.00	....	....	....	110,000.00
19	Iowa	683,708.52	....	....	....	121,608.00
20	Kansas	492,381.36	....	....	....	126,750.00
21	Kentucky (Lexington)	144,075.00	....	....	....	465,392.00
22	Kentucky (Frankfort)	20,925.00	....	....	....	25,100.00
23	Louisiana (Baton Rouge)	182,313.00	136,000.00	....	....	151,040.00
24	Louisiana (New Orleans)	....	....	....	....	40,000.00
25	Maine	118,300.00	....	100,000.00	....	50,000.00
26	Maryland (College Park)	118,000.00	....	....	....	30,000.00
27	Maryland (Princess Anne)	....	....	....	....	4,000.00
28	Massachusetts (Amherst)	219,000.00	....	142,000.00	....	43,850.00
29	Massachusetts (Boston)	....	....	2,085,409.57	....	2,573,648.00
30	Michigan	980,347.49	....	....	75,500.00	54,107.50
31	Minnesota	570,747.59	843,069.76	....	240.00	1,197,664.00
32	Mississippi (Agricultural College).	98,575.00	141,212.55	250.00	....	60,040.00
33	Mississippi (Alcorn)	113,575.00	96,296.00	....	....	6,000.00
34	Missouri (Columbia)	349,881.19	220,000.00	684,958.23	60,000.00	265,206.00
35	Missouri (Jefferson City)	....	....	....	....	20,000.00
36	Montana	[c] 186,797.39	....	....	292,100.00	31,000.00
37	Nebraska	444,000.00	154,486.00	....	200,000.00	300,000.00
38	Nevada	101,710.00	43,415.34	....	15,000.00	68,433.81

[a] Including grounds.
[b] Including apparatus.
[c] Including machinery.

at land-grant colleges, in 1908—Continued.

STUDENTS.

By courses—Continued.															
Blacksmithing.	Shoemaking.	Wheelwrighting.	Bricklaying.	Painting.	Printing.	Harness making.	Tailoring.	Plastering.	Sewing.	Cooking.	Laundering.	Nursing.	Millinery.	Military tactics.	
15	17	15	20	......	18	......	33	20	68	18	12	32	21	106	1
28	......	2	......	4	......	......	......	......	140	......	......	......	......	179	2
4	......	......	......	......	2	......	......	......	35	16	15	......	......	62	3
9	......	6	......	4	8	......	22	......	134	119	195	54	11	112	4
24	10	6	64	17	......	......	32	64	43	......	......	......	......	181	5
......	......	......	......	......	26	......	......	......	85	26	......	......	......	117	6
......	......	......	......	20	16	......	......	......	263	......	10	......	22	......	7
7	......	5	......	......	11	......	......	......	76	72	9	......	4	37	8
60	20	25	6	20	......	15	......	3	75	50	90	16	50	......	9
37	......	......	......	......	......	......	......	......	237	118	108	......	22	......	10
30	......	......	58	2	......	......	......	8	......	......	......	......	......	......	11
20	......	......	......	......	......	......	......	......	164	129	......	......	......	......	12
46	......	46	134	10	......	47	......	134	367	......	......	24	......	290	13
32	8	2	......	......	......	......	4	......	280	200	280	......	48	......	14
34	5	7	a 56	10	8	1	30	......	516	299	190	......	......	532	15
14	......	5	10	5	4	......	......	10	25	56	......	......	25	78	16
360	60	119	348	92	93	63	121	239	2,508	1,103	909	126	203	1,694	

[b] Including 3 post graduates.

equipment of land-grant colleges, 1908.

Buildings.	Apparatus.	Machinery.	Library.	Live stock.	Miscellaneous.	Total.	
$187,781.00	$27,943.71	$39,040.00	$100,522.00	$3,000.00	....	$620,786.71	1
67,053.00	6,960.00	4,091.00	500.00	600.00	$3,349.00	92,553.00	2
157,376.89	33,418.09	20,431.05	24,421.48	1,270.00	....	276,057.51	3
350,000.00	75,000.00	85,000.00	40,000.00	3,000.00	1,500.00	699,500.00	4
18,000.00	500.00	12,500.00	1,800.00	....	1,500.00	94,300.00	5
a 4,417,791.27	....	....	....	....	....	8,716,570.79	6
190,251.00	56,000.00	20,516.60	35,000.00	12,063.00	25,000.00	817,295.88	7
250,000.00	10,000.00	5,000.00	20,000.00	10,000.00	27,000.00	543,000.00	8
130,000.00	61,000.00	19,000.00	24,500.00	3,500.00	1,300.00	367,300.00	9
26,000.00	1,000.00	800.00	300.00	1,000.00	500.00	35,600.00	10
150,000.00	44,000.00	6,000.00	10,000.00	1,200.00	....	455,000.00	11
37,000.00	2,000.00	2,000.00	800.00	2,000.00	....	63,800.00	12
500,000.00	30,000.00	1,500.00	25,000.00	2,500.00	10,000.00	1,011,202.17	13
47,302.77	250.00	2,034.55	551.06	885.00	100.00	57,899.63	14
9,000.00	5,513.75	....	10,000.00	....	....	84,513.75	15
177,829.96	19,665.84	13,032.19	19,117.65	4,629.50	24,547.76	1,542,522.56	16
1,893,500.00	275,000.00	195,000.00	190,000.00	16,000.00	170,000.00	3,797,377.53	17
758,000.00	....	b 240,000.00	30,000.00	10,000.00	25,000.00	1,513,000.00	18
1,647,006.06	c 255,216.34	....	82,346.80	35,708.75	9,000.00	2,834,594.47	19
594,388.45	34,507.20	75,301.07	56,686.89	21,490.00	148,051.18	1,549,556.15	20
378,405.00	60,571.00	30,082.00	16,310.00	3,761.00	434,470.00	1,533,066.00	21
40,000.00	300.00	2,700.00	2,170.00	2,600.00	1,840.25	95,635.25	22
476,733.00	25,061.00	19,366.00	33,730.00	1,540.00	33,602.00	1,059,385.00	23
48,160.82	3,744.00	4,563.06	3,990.00	800.00	7,762.58	109,020.46	24
420,000.00	50,000.00	42,000.00	45,000.00	6,000.00	20,000.00	851,300.00	25
200,000.00	....	b 50,000.00	....	....	....	398,000.00	26
20,000.00	400.00	2,000.00	1,000.00	1,500.00	100.00	29,000.00	27
371,271.85	61,123.46	3,259.25	28,868.00	13,426.00	61,123.46	943,922.02	28
891,046.00	....	....	164,773.00	....	d 485,662.00	6,200,538.57	29
651,374.50	55,000.00	61,000.00	58,278.61	23,999.70	....	1,959,607.80	30
2,325,296.00	263,453.00	94,735.93	345,924.00	28,261.70	349,329.00	6,018,720.98	31
425,632.90	29,700.73	150,739.53	28,323.31	46,886.29	113,976.29	1,095,336.60	32
200,000.00	10,000.00	16,000.00	3,500.00	5,000.00	....	450,371.00	33
1,000,000.00	126,423.35	35,000.00	157,500.00	17,067.00	150,000.00	3,066,035.77	34
150,000.00	....	20,000.00	4,000.00	800.00	8,000.00	202,800.00	35
210,000.00	53,000.00	17,000.00	18,800.00	7,260.00	21,500.00	837,457.39	36
885,000.00	86,235.23	31,346.22	151,500.00	27,830.00	247,922.89	2,528,320.34	37
319,188.86	23,663.65	16,514.80	25,395.12	4,791.47	60,406.80	678,519.85	38

[d] Including apparatus and machinery.
[e] Including other land-grant funds.

TABLE 4.—*Value of permanent funds and equipment*

	State or Territory.	Land-grant fund of 1862.	Other land-grant funds.	Other permanent funds.	Land grant of 1862 still unsold.	Farms and grounds owned by the institution.
39	New Hampshire	$80,000.00		$70,000.00		$30,000.00
40	New Jersey	116,000.00		692,158.01		155,000.00
41	New Mexico		$19,231.47			46,500.00
42	New York	688,576.12		7,905,753.44		279,829.98
43	North Carolina (West Raleigh).	125,000.00				60,000.00
44	North Carolina (Greensboro).					27,000.00
45	North Dakota	811,050.00			$728,000.00	36,000.00
46	Ohio	524,176.58	97,356.12	206,466.34		1,540,000.00
47	Oklahoma (Stillwater)		500,000.00	1,000,000.00	500,000.00	40,000.00
48	Oklahoma (Langston)					8,000.00
49	Oregon	196,519.00			5,000.00	40,000.00
50	Pennsylvania	427,290.50		89,709.50		56,000.00
51	Porto Rico					19,000.00
52	Rhode Island	50,000.00				14,855.00
53	South Carolina (Clemson College).	95,900.00		58,539.00		56,800.00
54	South Carolina (Orangeburg).	95,900.00				40,000.00
55	South Dakota	62,287.59			1,562,020.00	65,000.00
56	Tennessee	400,000.00	5,000.00	22,000.00		285,475.00
57	Texas (College Station)	209,000.00				55,000.00
58	Texas (Prairie View)					15,000.00
59	Utah	183,442.77			70,827.00	23,200.00
60	Vermont	135,500.00		573,529.08		38,000.00
61	Virginia (Blacksburg)	344,312.00				61,200.00
62	Virginia (Hampton)	172,156.00		1,700,471.58		75,000.00
63	Washington	168,463.00	348,775.00		1,601,240.00	32,000.00
64	West Virginia (Morgantown).	114,169.00		26,704.17		200,000.00
65	West Virginia (Institute)					15,600.00
66	Wisconsin	303,359.61	288,263.95	82,889.51	340.00	1,500,000.00
67	Wyoming	21,450.57			900,000.00	45,000.00
	Total	13,010,284.52	3,460,801.00	18,726,387.04	6,997,485.27	12,004,682.77

[a] Including apparatus and machinery. [b] Including apparatus.

of land-grant colleges, 1908—Continued.

Buildings.	Apparatus.	Machinery.	Library.	Live stock.	Miscellaneous.	Total.	
$332,000.00	$30,000.00	$10,000.00	$25,000.00	$4,374.00	$20,000.00	$601,374.00	39
512,000.00	37,500.00	....	57,000.00	....	80,000.00	1,649,658.01	40
65,900.00	22,975.00	38,580.00	23,120.00	425,225.00	10,000.00	651,531.47	41
3,983,575.09	....	....	699,672.00	....	[a]1,126,442.50	14,683,849.13	42
269,900.00	24,612.00	101,491.00	5,592.00	5,857.00	44,965.13	637,417.13	43
70,530.00	....	11,667.93	2,026.51	2,851.00	[b]15,497.08	129,572.52	44
380,000.00	20,000.00	18,000.00	22,000.00	10,000.00	8,600.00	2,033,650.00	45
1,300,000.00	320,000.00	105,000.00	215,000.00	14,500.00	5,000.00	4,327,499.04	46
207,500.00	86,371.47	15,659.23	21,692.27	11,431.00	31,346.55	2,414,000.52	47
41,000.00	800.00	10,000.00	500.00	1,275.00	1,200.00	62,775.00	48
313,505.00	1,700.00	7,000.00	....	3,350.00	....	567,074.00	49
1,349,499.92	[c]150,000.00	....	60,000.00	3,161.75	....	2,135,661.67	50
42,350.00	1,200.00	....	1,665.00	1,125.00	3,500.00	68,840.00	51
188,716.57	[c]54,735.17	....	22,000.00	3,890.55	18,282.42	351,479.71	52
549,344.00	173,618.00	136,331.00	35,000.00	16,830.00	....	1,122,362.00	53
90,500.00	7,150.00	7,150.00	2,000.00	2,500.00	2,500.00	247,700.00	54
285,000.00	25,000.00	19,000.00	6,000.00	10,400.00	3,750.00	2,038,457.59	55
281,911.67	70,570.80	66,518.99	18,917.77	5,014.50	22,293.84	1,177,702.57	56
600,000.00	41,110.36	64,038.12	15,242.00	16,138.00	67,460.64	1,067,989.12	57
100,000.00	1,500.00	3,500.00	1,000.00	3,000.00	1,000.00	125,000.00	58
305,578.04	30,500.00	27,000.00	14,500.00	10,000.00	33,000.00	698,047.81	59
940,000.00	48,000.00	25,000.00	114,618.00	5,500.00	175,000.00	2,055,147.08	60
476,600.00	....	....	....	....	[d]100,000.00	982,112.00	61
700,000.00	....	....	9,100.00	15,319.00	[a]175,000.00	2,847,046.58	62
607,000.00	[c]115 000.00	....	50,000.00	10,000.00	....	2,932,478.00	63
536,000.00	17,000.00	43,000.00	57,000.00	1,500.00	51,000.00	1,046,373.17	64
117,600.00	4,549.00	14,475.00	4,975.00	1,908.00	11,746.00	170,853.00	65
1,880,178.89	384,157.70	18,626.83	291,600.22	26,597.00	105,097.24	4,881,110.95	66
255,000.00	77,400.00	41,700.00	50,000.00	5,900.00	10,000.00	1,406,450.57	67
37,401,578.51	3,532,099.85	2,121,291.35	3,585,828.69	937,016.21	4,565,224.61	106,342,679.82	

[c] Including machinery.

[d] Including all equipment.

TABLE 5.—*Revenue of land-grant colleges*

	State or Territory.	Federal aid.			State aid.	
		Interest on land grant of 1862.	Interest on other land grants.	Appropriation acts of 1890 and 1907.	Interest on endowment or regular appropriation.	Appropriation for current expenses.
1	Alabama (Auburn)	$20,280.00		$16,525.73		$34,700.00
2	Alabama (Normal)			13,474.27		4,000.00
3	Arizona			30,000.00		33,000.00
4	Arkansas (Fayetteville)	3,900.00		21,818.19		75,000.00
5	Arkansas (Pine Bluff)			8,181.81		14,500.00
6	California	38,339.73	$8,100.73	30,000.00	$39,270.00	429,119.17
7	Colorado	8,188.04		30,000.00		69,780.05
8	Connecticut	6,750.00		30,000.00		25,000.00
9	Delaware (Newark)	4,980.00		24,000.00		
10	Delaware (Dover)			6,000.00		
11	Florida (Gainesville)	4,994.00	1,938.00	15,000.00		17,391.05
12	Florida (Tallahassee)			15,000.00		5,000.00
13	Georgia (Athens)	16,954.14		20,000.00		10,000.00
14	Georgia (Savannah)			10,000.00		8,000.00
15	Hawaii			30,000.00		15,000.00
16	Idaho		27,000.00	30,000.00		13,850.00
17	Illinois	32,555.24		30,000.00		450,000.00
18	Indiana	17,000.00		30,000.00		161,535.39
19	Iowa	35,375.08		30,000.00		181,000.00
20	Kansas	27,109.61		30,000.00		140,000.00
21	Kentucky (Lexington)	8,644.50		25,650.00		70,818.32
22	Kentucky (Frankfort)	1,255.50		4,350.00		8,000.00
23	Louisiana (Baton Rouge)	9,115.69	5,440.00	15,790.35		25,000.00
24	Louisiana (New Orleans)			14,209.65		10,000.00
25	Maine	5,915.00		30,000.00		65,000.00
26	Maryland (College Park)	5,797.16		24,000.00		15,000.00
27	Maryland (Princess Anne)			6,000.00		
28	Massachusetts (Amherst)	3,650.00		20,000.00	3,313.00	16,739.17
29	Massachusetts (Boston)	5,306.68		10,000.00		25,000.00
30	Michigan	70,385.79		30,000.00		112,820.00
31	Minnesota	23,789.32		30,000.00	27,556.00	394,500.00
32	Mississippi (Agricultural College).	5,914.50	8,472.75	15,227.00		65,946.36
33	Mississippi (Alcorn)	6,814.50	5,777.77	14,773.00		8,000.00
34	Missouri (Columbia)	17,494.10	12,320.00	28,125.00	33,097.86	368,036.78
35	Missouri (Jefferson City)			1,875.00		29,900.00
36	Montana	8,000.00		30,000.00		25,000.00
37	Nebraska	32,000.00	13,000.00	30,000.00		
38	Nevada	4,580.20	3,949.23	30,000.00		42,500.00
39	New Hampshire	4,800.00		30,000.00		13,000.00
40	New Jersey	5,800.00		30,000.00		21,460.00
41	New Mexico			30,000.00		13,586.48
42	New York	34,428.80		30,000.00		180,000.00
43	North Carolina (West Raleigh)	7,500.00		20,100.00		32,000.00
44	North Carolina (Greensboro)			9,900.00		10,000.00
45	North Dakota	45,935.17		30,000.00		45,669.33
46	Ohio	31,450.59	5,309.52	30,000.00		358,312.39
47	Oklahoma (Stillwater)		[b] 3,331.32	27,000.00		30,000.00
48	Oklahoma (Langston)			3,000.00		35,400.39
49	Oregon	11,350.00		30,000.00		44,750.00
50	Pennsylvania	25,637.43		30,000.00	5,382.57	142,000.00
51	Porto Rico			30,000.00	19,452.29	20,000.00
52	Rhode Island	2,500.00		30,000.00		25,000.00
53	South Carolina (Clemson College).	5,754.00		15,000.00	168,115.28	
54	South Carolina (Orangeburg)	5,754.00		15,000.00		5,000.00
55	South Dakota	18,844.89		30,000.00		38,000.00
56	Tennessee	23,960.00	250.00	30,000.00		
57	Texas (College Station)	13,280.00		22,500.00		74,085.00
58	Texas (Prairie View)			7,500.00		19,350.00
59	Utah	7,282.14		30,000.00		45,000.00
60	Vermont	8,130.00		30,000.00	2,600.00	6,000.00
61	Virginia (Blacksburg)	20,658.00		20,000.00		56,666.66
62	Virginia (Hampton)	10,329.36		10,000. 0		
63	Washington	10,000.00		30,000.00		217,000.00
64	West Virginia (Morgantown)	5,400.00		24,000.00	1,000.00	89,500.00
65	West Virginia (Institute)			6,000.00		28,450.00
66	Wisconsin	13,847.27	13,038.27	30,000.00		687,657.00
67	Wyoming		4,844.63	30,000.00		23,747.13
	Total	737,730.43	112,772.22	1,500,000.00	299,787.00	5,230,770.67

[a] Including tuition fees.

[b] Rentals from reserved lands.

for year ended June 30, 1908.

State aid—Appropriations for buildings or for other special purposes.	Income from endowment other than Federal or State grants.	Fees and all other sources.—Tuition fees.	Fees and all other sources.—Incidental fees.	Fees and all other sources.—Miscellaneous.	Total.	United States appropriations for experiment stations (acts of 1887 and 1906).	
$86,500.00		$1,340.00	$2,772.00	$8,004.00	$170,121.73	$24,000.00	1
		307.50	176.50	698.13	18,656.40		2
		475.00	1,292.00	17,235.66	82,002.66	24,000.00	3
50,000.00			13,700.00	250.00	164,668.19	24,000.00	4
		400.00			23,081.81		5
229,266.27	$137,520.88	28,251.35	61,552.08	1,018,812.82	2,020,233.03	24,000.00	6
34,133.84				9,934.29	152,036.22	24,000.00	7
36,500.00	4,800.00			50,698.16	153,748.16	12,000.00	8
		90.00	7,923.53	1,328.73	38,322.26	24,000.00	9
2,500.00					8,500.00		10
5,910.65		20.00	467.35		45,721.05	24,000.00	11
					20,000.00		12
100,000.00			275.00		147,229.14		13
				978.72	18,978.72		14
10,000.00					55,000.00		15
85,000.00				2,512.73	158,362.73	24,000.00	16
596,445.00			205,960.91	69,936.98	1,384,898.13	24,000.00	17
		11,185.00	53,747.25	10,050.10	283,517.74	24,000.00	18
239,883.20	3.20	2,810.00	49,813.68	3,079.38	541,964.54	24,000.00	19
161,250.00			14,447.00		372,806.61	24,000.00	20
		4,450.00	3,370.00	3,485.72	116,418.54	24,000.00	21
40,000.00			438.18	5,777.57	59,821.25		22
44,150.00		3,105.00	10,504.50	4,071.54	117,177.08	24,000.00	23
				313.00	24,522.65		24
60,000.00	4,000.00	33,178.00	15,000.00	18,592.09	231,685.09	24,000.00	25
23,000.00		28,244.47		11,715.27	107,756.90	24,000.00	26
			1,479.00	1,500.00	8,979.00		27
55,000.00		640.00		26,241.59	125,583.76	24,000.00	28
	77,177.48	313,107.00	12,638.78	61,937.00	505,166.94		29
61,981.24		1,075.00	6,657.50	59,310.16	342,229.09	24,000.00	30
695,296.36	50,000.00	139,948.84		35,251.32	1,396,341.84	24,000.00	31
112,250.00	250.00	750.00	10,913.25	80,394.32	300,118.18	24,000.00	32
16,000.00				16,077.30	67,442.57		33
	300.00		35,581.23	121,241.83	616,196.80	24,000.00	34
					31,775.00		35
59,000.00		3,350.09	1,238.66		126,588.75	24,000 00	36
364,400.00	1,000.00	14,628.00	40,784.00	43,033.00	538,845.00	24,000 00	37
32,070.39	6,032.00		7,000.00	2,920.17	129,051.99	24,000.00	38
34,000.00	3,292.00	3,696.00	1,994.46	64,665.04	155,447.50	24,000.00	39
25,000.00	24,877.53		[a] 14,899.51	4,533.67	126,570.71	24,000.00	40
	580.48	2,051.00	300.00	9,859.73	56,377.69	24,000.00	41
87,127.10	394,407.01	336,106.14	99,929.31	339,497.45	1,501,495.81	21,600.00	42
76,000.00		19,432.17	10,690.62	7,325.02	173,047.81	24,000.00	43
8,925.00		411.90	185.60	9,903.83	39,326.33		44
			4,700.00	5,648.90	131,953.40	24,000.00	45
180,641.15	13,897.79	55,990.94		57,894.53	733,496.91		46
			2,060.00	66,088.87	128,480.19	24,000.00	47
					38,400.39		48
130,000.00			4,617.00	3,634.00	224,351.00	24,000.00	49
179,530.92		1,988.70	31,748.48	66,763.68	483,051.78	24,000.00	50
5,460.00		56.50		2,820.71	77,789.50		51
60,858.05		871.19	1,044.13	28,211.41	148,484.78	24,000.00	52
	3,512.36	1,550.00		7,546.11	201,477.75	24,000.00	53
3,000.00					28,754.00		54
25,000.00		4,244.00	3,643.00	9,006.79	128,738.68	24,000.00	55
50,000.00			20,583.40	18,230.17	143,023.57	24,000.00	56
103,200.00			3,115.00	1,000.00	217,180.00	24,000.00	57
29,500.00			2,000.00	24,000.00	82,350.00		58
15,000.00		3,165.00	2,405.00	15,289.30	118,141.44	24,000.00	59
	28,218.82	[c] 29,141.73		3,873.06	107,963.61	24,000.00	60
31,000.00		2,595.00	29,805.44	3,321.63	167,046.73	24,000.00	61
	74,573.05		3,414.00	144,235.78	242,552.19		62
370,500.00					627,500.00	24,000.00	63
35,200.00				[d] 25,524.67	180,624.67	24,000.00	64
4,000.00		228.00		960.00	39,638.00		65
139,875.67	4,013.80	20,863.25	65,877.00	170,384.76	1,145,557.02	24,000.00	66
21,712.89		1,035.25		3,081.34	84,421.24	24,000.00	67
4,819,067.73	828,456.40	1,070,782.02	860,744.35	2,778,682.03	18,238,792.85	1,089,600.00	

[c] Including incidental fees.

[d] Including tuition and incidental fees.

TABLE 6.—*Additions to equipment of land-grant colleges, 1908.*

State or Territory.	Permanent endowment.	Buildings.	Library.	Apparatus.	Machinery.	Live stock.	Miscellaneous.	Total.
Alabama (Auburn)		$32,280.35	$1,862.00	$4,149.71	$13,552.00			$51,844.06
Alabama (Normal)		1,608.00						1,608.00
Arizona	$10,000.00	4,018.00	2,147.43	3,492.14	696.47			20,354.04
Arkansas (Fayetteville)			750.00	3,000.00	1,500.00	$1,000.00	$1,000.00	7,250.00
Arkansas (Pine Bluff)				300.00	500.00			800.00
California	273,313.45	780,813.69	20,509.36	20,000.00	3,000.00	5,000.00		1,102,636.50
Colorado			2,555.85					2,555.85
Connecticut		40,000.00	300.00	612.74	630.00	1,300.00	2,466.00	45,308.74
Delaware (Newark)		600.00	1,150.00	1,500.00	1,000.00	1,000.00	800.00	6,050.00
Delaware (Dover)								
Florida (Gainesville)		10,419.09	959.40	3,268.82	785.69	429.97	313.50	16,176.47
Florida (Tallahassee)			500.00	1,000.00	100.00			1,600.00
Georgia (Athens)		103,000.00	2,000.00	500.00	700.00	1,350.00	1,600.00	109,150.00
Georgia (Savannah)	1,666.67	3,249.48	51.06		34.55	470.00		5,471.76
Hawaii		9,000.00	7,364.70	5,513.75				21,878.45
Idaho	78,571.63	64,823.23	2,391.30	16,454.10	4,093.36	249.53	902.47	167,485.62
Illinois	2,436.00	100,000.00	25,000.00	25,000.00	30,000.00	2,000.00	10,000.00	194,436.00
Indiana		43,403.23	3,033.90	a9,487.72		1,547.04		57,471.89
Iowa		231,305.41	3,249.45	16,878.06		4,342.15	4,640.91	260,415.98
Kansas		140,000.00	2,900.00	4,000.00	6,000.00	600.00	16,000.00	169,500.00
Kentucky (Lexington)		79,212.82	1,516.71	2,327.34	1,876.95		1,448.63	86,382.45
Kentucky (Frankfort)			50.00		393.75			443.75
Louisiana (Baton Rouge)		27,694.11	1,352.41	2,944.99	546.99		2,248.26	34,786.76
Louisiana (New Orleans)								
Maine		75,000.00	5,500.00	6,000.00	2,000.00			88,500.00
Maryland (College Park)			438.82	5,000.00				5,438.82
Maryland (Princess Anne)		250.00	125.00	150.00	320.00	70.00	180.00	1,095.00
Massachusetts (Amherst)		66,091.85	868.00	3,054.00	2,451.65	4,000.00	13,494.35	89,959.85
Massachusetts (Boston)	56,852.75		2,814.37					59,667.12
Michigan		20,000.00	2,500.00	15,000.00	25,000.00			62,500.00
Minnesota	161,025.83	279,927.67	12,343.74	7,840.00	4,492.00	3,981.85		469,611.09
Mississippi (Agricultural College)		35,650.00	2,071.53	3,608.86	962.00	8,445.00	7,032.61	57,770.00
Mississippi (Alcorn)			40.00		16,000.00		8,000.00	24,040.00
Missouri (Columbia)	8,000.00		10,000.00	676.67	5,000.00	567.00	100.00	24,343.67
Missouri (Jefferson City)								
Montana	65,411.71	87,000.00	1,500.00	6,240.00	1,300.00	2,000.00		163,451.71
Nebraska		113,500.00	6,250.00	8,500.00	3,250.00	5,350.00	20,000.00	156,850.00
Nevada	6,400.00	100,000.00	2,527.23	12,456.88	636.90	1,323.12	2,102.82	125,446.95
New Hampshire	300.00	28,500.00	10,187.00	2,000.00	450.00	218.00	500.00	42,155.00
New Jersey	43,741.07	7,530.00	4,155.45	1,690.60	839.66	390.00	650.81	58,997.59
New Mexico		2,400.00	1,081.42	2,200.00	9,500.00	1,257.25		16,438.67
New York	98,796.53	23,278.38	18,989.00				170,713.12	311,777.03
North Carolina (West Raleigh)		6,000.00	400.00	8,000.00	50,000.00	2,500.00		66,900.00
North Carolina (Greensboro)			147.51	a368.10		506.25		1,021.86

North Dakota	....	89,906.62	1,624.45	1,095.32	1,489.55	2,165.20	4,237.26	100,518.40
Ohio	20,268.49	166,447.09	10,000.00	4,787.90	6,799.80	244,33	....	208,547.61
Oklahoma (Stillwater)	500,000.00	....	1,425.00	3,662.07	2,174.10	650.00	1,000.00	508,911.17
Oklahoma (Langston)	....	....	350.00	400.00	....	75.00	....	825.00
Oregon	....	133,505.00	1,250.00	10,000.00	8,000.00	....	....	152,755.00
Pennsylvania	....	133,100.00	....	....	....	3,161.75	....	136,261.75
Porto Rico	....	389.46	100.36	432.60	....	486.23	927.58	2,336.23
Rhode Island	....	5,858.05	1,832.00	*a* 5,500.00	....	686.00	....	13,876.05
South Carolina (Clemson College)	....	29,437.91	....	....	....	....	3,476.15	32,914.06
South Carolina (Orangeburg)	....	2,000.00	....	....	....	....	....	2,000.00
South Dakota	....	25,000.00	750.00	2,000.00	1,750.00	400.00	....	29,900.00
Tennessee	....	43,763.00	1,415.37	10,697.06	7,672.75	330.00	4,990.90	68,869.08
Texas (College Station)	....	71,500.00	....	9,000.00	2,000.00	6,000.00	....	88,500.00
Texas (Prairie View)	....	27,500.00	200.00	500.00	500.00	1,000.00	500.00	30,200.00
Utah	....	....	454.41	503.41	1,090.41	2,337.11	1,099.45	5,484.79
Vermont	9,485.75	2,500.00	2,421.00	4,000.00	....	1,000.00	....	19,406.75
Virginia (Blacksburg)	....	3,600.00	500.00	....	5,000.00	....	....	9,100.00
Virginia (Hampton)	182,245.36	20,528.08	100.00	*b* 3,000.00	....	....	....	205,873.44
Washington	....	312,000.00	950.00	1,250.00	300.00	2,500.00	1,000.00	318,000.00
West Virginia (Morgantown)	....	16,000.00	4,000.00	2,000.00	5,000.00	....	3,200.00	30,200.00
West Virginia (Institute)	....	....	400.00	450.00	840.00	125.00	180.00	1,995.00
Wisconsin	20,389.51	75,509.58	33,293.94	68,584.36	....	....	12,516.73	210,294.12
Wyoming	....	30,000.00	2,750.00	3,430.00	2,164.00	2,299.00	....	40,643.00
Total	1,538,904.75	3,705,100.10	225,399.17	334,507.20	232,392.58	73,356.78	297,321.55	6,406,982.13

a Including machinery.

b Including machinery and other equipment.

TABLE 7.—*Disbursements from the United States Treasury to the States and Territories of the appropriations in aid of colleges of agriculture and the mechanic arts under the acts of Congress approved August 30, 1890, and March 4, 1907.*[a]

State or Territory.	Year ending June 30—												
	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	[b] 1900.	1908.	1909.
Alabama	$15,000	$16,000	$17,000	$18,000	$19,000	$20,000	$21,000	$22,000	$23,000	$24,000	$25,000	$30,000	$35,000
Arizona	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Arkansas	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
California	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Colorado	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Connecticut	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Delaware	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Florida	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Georgia	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Hawaii	...	...	...	...	...	...	...	...	...	...	...	...	35,000
Idaho	...	...	...	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Illinois	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Indiana	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Iowa	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Kansas	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Kentucky	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Louisiana	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Maine	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Maryland	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Massachusetts	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Michigan	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Minnesota	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Mississippi	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Missouri	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Montana	...	...	...	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Nebraska	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Nevada	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
New Hampshire	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
New Jersey	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
New Mexico	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
New York	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
North Carolina	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
North Dakota	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Ohio	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Oklahoma	...	...	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Oregon	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Pennsylvania	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Porto Rico	...	...	...	...	...	...	...	...	...	...	...	...	35,000
Rhode Island	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
South Carolina	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000

South Dakota	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Tennessee	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Texas	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Utah	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Vermont	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Virginia	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Washington			17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
West Virginia	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Wisconsin	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Wyoming	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	30,000	35,000
Total	660,000	704,000	782,000	864,000	912,000	960,000	1,008,000	1,056,000	1,104,000	1,152,000	1,200,000	1,440,000	1,750,000

[a] From the annual statement of Commissioner of Education to the Secretary of the Interior, 1908.

[b] For each of the years ended June 30, 1901, 1902, 1903, 1904, 1905, 1906, and 1907 the sum of $25,000 was paid to each of the 48 States and Territories included in this tabular statement, the total amount disbursed for each of said years being $1,200,000.

STATISTICS OF THE AGRICUL

TABLE 8.—*General*

Station.	Location.	Director.	Date of original organization.	Date of organization under Hatch Act.
Alabama (College)	Auburn	J. F. Duggar, M. S	Feb. —, 1883	Feb. 24, 1888
Alabama (Canebrake)	Uniontown	F. D. Stevens, B. S	Jan. 1, 1886	Apr. 1, 1888
Alabama	Tuskegee Institute	G.W. Carver, M.S. Agr.	Feb. 15, 1897	
Arizona	Tucson	R. H. Forbes, M. S		1889
Arkansas	Fayetteville	W. G. Vincenheller		Mar. 7, 1889
California	Berkeley	E. J. Wickson, A. M	1873	Mar. —, 1888
Colorado	Fort Collins	L. G. Carpenter, M. S		Feb. —, 1888
Connecticut (State)	New Haven	E. H. Jenkins, Ph. D	Oct. 1, 1875	May 18, 1887
Connecticut (Storrs)	Storrs	L. A. Clinton, M. S		May 18, 1887
Delaware	Newark	H. Hayward, M. S. Agr.		Feb. 21, 1888
Florida	Gainesville	P. H. Rolfs, M. S		1888
Georgia	Experiment	M. V. Calvin	Feb. 18, 1888	July 1, 1889
Idaho	Moscow	H. T. French, M. S		Feb. 26, 1892
Illinois	Urbana	E. Davenport, LL. D		Mar. 21, 1888
Indiana	Lafayette	A. Goss, M. S., A. C	1885	Jan. —, 1888
Iowa	Ames	C. F. Curtiss, M. S. A		Feb. 17, 1888
Kansas	Manhattan	J. T. Willard		Feb. 8, 1888

TURAL EXPERIMENT STATIONS.

statistics, 1908.

Number on staff.	Number of teachers on staff.	Number of persons on staff who assist in farmers' institutes.	Publications during fiscal year 1908.		Number of names on mailing list.	Principal lines of work.
			Number.	Pages.		
19	13	13	5	286	17,300	Field experiments; plant breeding; soil improvement; feeding experiments; entomology; diseases of plants and animals; analyses of fertilizers.
1	....	....	1	16	1,800	Soil improvement; field experiments; horticulture; plant breeding; diseases of plants.
19	19	19	2	23	1,500	Field experiments; horticulture; plant breeding; diseases of plants; animal industry; poultry investigations; dairying.
12	2	5	12	159	7,000	Chemistry; botany; field experiments; improvement of ranges; horticulture, including date-palm culture; sheep breeding experiments; plant diseases; irrigation.
13	7	6	7	256	17,000	Chemistry; soil physics; field experiments; horticulture; plant breeding; diseases of plants; animal husbandry and pathology; feeding and breeding experiments; entomology; nursery inspection; dairying; poultry experiments.
57	43	15	12	240	11,500	Chemistry; soils; bacteriology; fertilizer control; field crops; horticulture, including date culture, viticulture, and zymology; botany; meteorology; animal husbandry; entomology; dairying; poultry culture; drainage and irrigation; sylviculture; reclamation of alkali lands; animal and plant pathology; nutrition investigations.
24	12	16	10	270	14,000	Chemistry; meteorology; field experiments; horticulture; forestry; plant breeding; diseases of plants; animal husbandry; veterinary investigations; entomology; bacteriology; irrigation.
16	....	6	5	572	9,000	Chemistry; analysis and inspection of fertilizers, foods, drugs, and feeding stuffs; inspection of Babcock-test apparatus and nurseries; diseases of plants; plant selection and breeding; seed testing; forestry; field experiments; entomology; investigation of vegetable proteids.
12	6	6	6	343	10,000	Bacteriology of dairy products; field experiments; horticulture; feeding and breeding experiments; poultry experiments; dairying, including soft-cheese manufacture; embryology.
9	7	7	6	210	5,000	Chemistry; field experiments; horticulture; plant breeding; diseases of plants and animals; entomology.
15	....	7	5	139	12,203	Chemistry; soils; field experiments; horticulture; plant physiology; diseases of plants; feeding experiments; entomology.
10	....	10	4	106	15,000	Chemistry; field experiments; bacteriology; horticulture; plant breeding; plant diseases; entomology; feeding experiments; dairying.
9	6	7	5	135	6,900	Chemistry; physics; botany; field experiments; horticulture; plant breeding and diseases; entomology; animal husbandry; irrigation; dairying; dry farming; wheat investigations; fruit by-products.
47	24	24	21	752	40,000	Chemistry; soil physics; bacteriology; pot and field experiments; horticulture; forestry; plant breeding; animal husbandry; diseases of plants and animals; dairying; entomology.
31	10	15	11	315	26,911	Chemistry; soils; field experiments; breeding and feeding experiments; horticulture; plant breeding; diseases of plants and animals; entomology; dairying; feeding stuff and fertilizer control; agricultural extension work.
27	16	10	8	240	20,487	Chemistry; botany; soils; field experiments; horticulture; plant breeding; forestry; diseases of plants; animal husbandry; poultry investigations; entomology; dairying; rural engineering; good roads investigations.
33	20	9	9	288	26,903	Soils; inspection of feeding stuffs and fertilizer control; horticulture; plant breeding; field experiments; feeding and digestion experiments; milling and baking tests; correlation of characteristics of wheat; poultry experiments; diseases of animals; hog-cholera serum; entomology; dairying; extermination of prairie dogs and gophers; irrigation.

TABLE 8.—*General statis*

Station.	Location.	Director.	Date of original organization.	Date of organization under Hatch Act.
Kentucky	Lexington	M. A. Scovell, Ph. D.	Sept. —, 1885	Apr. —, 1888
Louisiana (Sugar)	New Orleans	W. R. Dodson, B. S. A.	Sept. —, 1885	
Louisiana (State)	Baton Rouge	do	Apr. —, 1886	
Louisiana (North)	Calhoun	do	May —, 1887	
Maine	Orono	C. D. Woods, Sc. D.	Mar. —, 1885	Oct. 1, 1887
Maryland	College Park	H. J. Patterson, B. S.	1888	Apr. —, 1888
Massachusetts	Amherst	W. P. Brooks, Ph. D.	[a]1882	Mar. 2, 1888
Michigan	East Lansing	R. S. Shaw		Feb. 26, 1888
Minnesota	St. Anthony Park, St. Paul.	E. W. Randall	Mar. 7, 1885	1888
Mississippi	Agricultural College	W. L. Hutchinson, M. S.		Jan. 27, 1888
Missouri (College)	Columbia	H. J. Waters, B. S. A.		Jan. —, 1888
Missouri (Fruit)	Mountain Grove	Paul Evans	Feb. 1, 1900	
Montana	Bozeman	F. B. Linfield, B. S. A.		July 1, 1893
Nebraska	Lincoln	E. A. Burnett, B. S.	Dec. 16, 1884	June 13, 1887
Nevada	Reno	J. E. Stubbs, D.D., LL. D.		Dec. —, 1887
New Hampshire	Durham	E. D. Sanderson, B. S. A.		Aug. 4, 1887

[a] In 1882 the State organized a station here and maintained it until June 18, 1895, when it was combined with the Hatch Station at the same place.

tics, 1908—Continued.

Number on staff.	Number of teachers on staff.	Number of persons on staff who assist in farmers' institutes.	Publications during fiscal year 1908.		Number of names on mailing list.	Principal lines of work.
			Number.	Pages.		
23	....	6	5	576	11,000	Chemistry; soils; bacteriology; inspection of fertilizers, foods, feeding stuffs, seeds, orchards, and nurseries; field experiments; horticulture; plant breeding; animal husbandry; diseases of plants and animals; entomology; apiculture; dairying.
29	3	6	17	692	15,000	Chemistry; bacteriology; soils; field experiments; horticulture; sugar making; drainage; irrigation. Geology; botany; bacteriology; soils; inspection of fertilizers, feeding stuffs, and Paris green; field experiments; horticulture; fertilizer and variety tests with rice; animal husbandry; diseases of animals; entomology. Chemistry; soils; fertilizers; field experiments; horticulture; feeding experiments; stock raising; poultry experiments; dairying.
18	1	....	41	857	13,000	Chemistry; botany; analysis and inspection of foods, fertilizers, concentrated commercial feeding stuffs, and agricultural seeds; calibration of creamery glassware; vegetable pathology; biology, including poultry breeding; plant breeding; entomology.
20	4	7	11	327	28,000	Chemistry; fertilizers; field experiments; horticulture; plant breeding; diseases of plants and animals; feeding experiments; animal breeding; poultry raising; entomology; dairying.
28	7	8	16	467	19,541	Chemistry; meteorology; analysis and inspection of fertilizers and concentrated commercial feeding stuffs; inspection of creamery glassware and nurseries; pot, cylinder, and field experiments; horticulture; plant breeding; diseases of plants and animals; digestion and feeding experiments; entomology; dairying; effect of electricity on plant growth.
26	5	3	16	807	42,000	Chemistry; analysis and control of fertilizers; bacteriology; field experiments; horticulture; forestry; plant breeding; diseases of plants and animals; feeding and breeding experiments; poultry culture; entomology; stable hygiene.
28	15	....	9	614	15,767	Chemistry; soils; fertilizers; field experiments; horticulture; forestry; diseases of plants and animals; plant and animal breeding; animal nutrition; entomology; dairying; farm management; ventilation; farm statistics.
16	7	8	9	146	22,000	Fertilizers; field experiments; horticulture; biology; plant breeding; animal husbandry; diseases of animals; poultry culture; entomology; dairying; agricultural engineering.
37	21	15	12	365	12,000	Chemistry; soil survey; botany; field experiments; horticulture; diseases of plants and animals; feeding experiments; animal and plant breeding; entomology; dairying.
6	....	....	6	156	6,000	Horticulture; vegetable pathology; entomology; inspection of orchards and nurseries.
14	9	11	8	192	6,850	Chemistry; meteorology; botany; field experiments; dry farming; horticulture; feeding and breeding experiments; poultry experiments; entomology; dairying; irrigation and drainage.
26	20	13	8	392	21,100	Chemistry; botany; meteorology; soils; field experiments; horticulture; plant breeding; diseases of plants and animals; forestry; feeding and breeding experiments; entomology; dairying; irrigation.
12	2	12	1	50	4,238	Chemistry; meteorology; botany; soils; field experiments; horticulture; plant breeding; forestry; animal feeding and breeding; plant diseases; veterinary science and bacteriology; zoology; entomology; irrigation.
14	12	5	8	142	12,999	Chemistry; botany; field experiments; horticulture; plant breeding; breeding experiments; entomology; dairying.

TABLE 8.—*General statis*

Station.	Location.	Director.	Date of original organization.	Date of organization under Hatch Act.
New Jersey (State)	New Brunswick	E. B. Voorhees, D. Sc.	Mar. 10, 1880	
New Jersey (College)	do	do		Apr. 26, 1888
New Mexico	Agricultural College	L. Foster, M. S		Dec. 14, 1889
New York (State)	Geneva	W. H. Jordan, D. Sc., LL. D.	Mar. —, 1882	
New York (Cornell)	Ithaca	L. H. Bailey, M. S., LL. D.	1879	Apr. —, 1888
North Carolina (College)	West Raleigh	C. B. Williams, M. S.	Mar. 12, 1877	Mar. 7, 1887
North Carolina (State)	Raleigh	B. W. Kilgore, M. S.	July 1, 1907	
North Dakota	Agricultural College	J. H. Worst, LL. D.		Mar. —, 1890
Ohio	Wooster	C. E. Thorne, M. S. A.	Apr. 25, 1882	Apr. 2, 1888
Oklahoma	Stillwater	B. C. Pittuck		Dec. 25, 1890
Oregon	Corvallis	J. Withycombe, M. Agr.		July —, 1888
Pennsylvania	State College	T. F. Hunt, D. Agr., D. Sc.		June 30, 1887
Rhode Island	Kingston	H. J. Wheeler, Ph. D.		July 30, 1888
South Carolina	Clemson College	J. N. Harper, M. Agr.		Jan. —, 1888
South Dakota	Brookings	J. W. Wilson, M. S. A.		Mar. 13, 1887
Tennessee	Knoxville	H. A. Morgan, B. S. A.	June 8, 1882	Aug. 4, 1887
Texas	College Station	H. H. Harrington, LL. D.		1888
Utah	Logan	E. D. Ball, Ph. D.		1890

tics, 1908—Continued.

Number on staff.	Number of teachers on staff.	Number of persons on staff who assist in farmers' institutes.	Publications during fiscal year 1908.		Number of names on mailing list.	Principal lines of work.
			Number.	Pages.		
12	4	4	7	352	8,051	Chemistry; oyster culture; botany; analysis of fertilizers, foods, commercial feeding stuffs, and insecticides; pot, cylinder, and field experiments; horticulture; plant breeding; diseases of plants and animals; entomology; dairy husbandry; soil chemistry and bacteriology; irrigation.
10	5	5	5	578		
18	17	3	3	134	3,600	Chemistry; botany; soils; field experiments; dry farming; horticulture; cactus and guayule plant investigations; feeding experiments; entomology; dairying; irrigation.
28	....	16	19	864	45,000	Chemistry; bacteriology; meteorology; fertilizers; analysis and control of fertilizers; inspection of feeding stuffs, Paris green, and creamery glassware; field experiments; horticulture; plant breeding; diseases of plants; feeding experiments; poultry experiments; entomology; dairying; irrigation.
33	....	....	13	595	18,500	Chemistry; soils; field experiments; horticulture; plant breeding; diseases of plants; feeding and breeding experiments; poultry experiments; entomology; dairying.
17	9	5	4	188	32,000	Chemistry; soils; field experiments; horticulture; nitrification experiments; diseases of plants and animals; animal husbandry; poultry experiments; dairying; tests of farm machinery.
24	....	7	12	607	33,000	Chemistry; soils; field experiments; horticulture; diseases of animals; feeding experiments; entomology; fertilizer experiments and analyses; inspection of foods and stock feeds; cooperative demonstration work with farmers; farmers' institutes.
27	10	....	6	497	14,500	Chemistry; soils; botany; field experiments; plant breeding; horticulture; forestry; diseases of plants and animals; analysis of foods and spraying materials; inspection and analysis of paints, drugs, proprietary products and feeding stuffs; feeding and breeding experiments; poultry experiments; milling and chemical tests of wheat; drainage; farm engineering
32	....	12	22	403	38,000	Chemistry; soils; field experiments; botany; horticulture; plant breeding; forestry; diseases of plants; feeding experiments; entomology; nutrition; farm management.
10	7	7	12	233	24,390	Chemistry; field experiments; horticulture; plant and animal breeding; forestry; botany; bacteriology; diseases of plants and animals; animal husbandry; entomology.
24	12	7	5	129	9,861	Chemistry; bacteriology; soils: fertilizers; field crops; horticulture; plant breeding and selection; diseases of plants; feeding experiments; poultry experiments entomology; dairying; irrigation.
34	18	12	5	84	22,100	Chemistry; meteorology; fertilizers; horticulture; forestry; plant diseases; field experiments; feeding experiments; dairying; poultry experiments.
15	3	3	9	408	10,000	Chemistry; meteorology; soils; analysis and inspection of fertilizers and feeding stuffs; field and pot experiments; horticulture; poultry and pigeon breeding; poultry experiments.
11	12	6	10	268	14,400	Chemistry; analysis and control of fertilizers; soils; botany; field experiments; horticulture; plant breeding; diseases of plants; feeding and breeding experiments; veterinary science; entomology; dairying.
16	10	4	6	148	16,000	Chemistry; botany; horticulture; field experiments; plant breeding; diseases of plants and animals; animal husbandry; entomology; dairying.
21	8	7	1	18	12,265	Chemistry; soil investigations; inspection of fertilizers; field experiments; horticulture; plant breeding; seeds; weeds; diseases of plants and animals; feeding experiments; entomology; dairying; poultry investigations; apiculture.
16	7	5	6	218	35,000	Chemistry; seed testing and feed inspection; botany and mycology; soils; field experiments; horticulture; plant breeding; feeding experiments; diseases of plants and animals; entomology; irrigation.
18	10	9	1	40	7,797	Chemistry of soils; field experiments; horticulture; diseases of plants and animals; breeding and feeding experiments; dairying; poultry experiments; entomology; irrigation; arid farming.

TABLE 8.—*General statis*

Station.	Location.	Director.	Date of original organization.	Date of organization under Hatch Act.
Vermont	Burlington	J. L. Hills, Sc. D	Nov. 24, 1886	Feb. 28, 1888
Virginia	Blacksburg	S. W. Fletcher, Ph. D.		Oct. 16, 1888
Washington	Pullman	R. W. Thatcher, B. S., M. A.		1891
West Virginia	Morgantown	J. H. Stewart, M. A.		June 11, 1888
Wisconsin	Madison	H. L. Russell, Ph. D.	1883	1887
Wyoming	Laramie	J. D. Towar, M. S.		Mar. 1, 1891
Total				

tics, 1908—Continued.

Number on staff.	Number of teachers on staff.	Number of persons on staff who assist in farmers' institutes.	Publications during fiscal year 1908.		Number of names on mailing list.	Principal lines of work.
			Number.	Pages.		
16	8	4	8	488	13,500	Chemistry; botany; bacteriology; analysis and control of fertilizers and feeding stuffs; inspection of creamery glassware; State nursery for forest-tree seedlings; horticulture; diseases of plants; feeding and breeding experiments; dairying.
19	9	....	5	172	15,500	Chemistry; biology; field experiments; horticulture; plant breeding; soil bacteriology; mycology; analysis of foods and soils; breeding and feeding experiments; veterinary science; entomology; cider and vinegar making; ferments; dairying.
18	12	10	14	304	9,620	Chemistry; botany; bacteriology; soils; field experiments; horticulture; plant breeding; diseases of plants; feeding and breeding experiments; veterinary science; entomology; dairying; irrigation; dry farming.
14	3	3	8	247	5,946	Chemistry; effect of pressure in the preservation of fruits, vegetables, and milk; artificial fixation of atmospheric nitrogen; analysis and control of fertilizers; soils; field experiments; horticulture; diseases of plants and animals; inspection of orchards and nurseries; feeding and breeding experiments; poultry experiments; entomology; dairying.
47	29	10	16	913	23,000	Chemistry; bacteriology; soils; field experiments; agronomy; tobacco and cranberry culture; horticulture; plant breeding; breeding and feeding experiments; dairying; irrigation and drainage; agricultural engineering.
12	6	8	6	384	4,800	Chemistry; mycology; botany; meteorology; soils; range improvement; fertilizers; field experiments; plant selection; food analysis; breeding and feeding experiments; wool investigation; irrigation.
1,143	490	416	499	18,405	888,829	

TABLE 9.—*Revenue and*

	Station.	Federal. Hatch fund.	Federal. Adams fund.	State.	Individuals and communities.	Fees.	Farm products.
1	Alabama (College)	$15,000.00	$9,000.00	$13,107.25			$266.62
2	Alabama (Canebrake)			2,500.00			1,270.10
3	Alabama (Tuskegee)			1,500.00			
4	Arizona	15,000.00	9,000.00	5,252.53	$2,500.00		1,628.09
5	Arkansas	15,000.00	9,000.00	[c] 35,152.97			10,577.44
6	California	15,000.00	9,000.00	120,047.18		$8,306.38	8,881.87
7	Colorado	15,000.00	9,000.00	[d] 27,500.00			
8	Connecticut (State)	7,500.00	4,500.00	19,000.00	9,847.40	7,299.98	279.02
9	Connecticut (Storrs)	7,500.00	4,500.00	1,800.00			
10	Delaware	15,000.00	9,000.00				1,475.59
11	Florida	15,000.00	9,000.00	1,030.20		70.00	1,664.74
12	Georgia	15,000.00	9,000.00	710.10			2,099.37
13	Idaho	15,000.00	9,000.00				1,671.38
14	Illinois	15,000.00	9,000.00	102,500.00			13,430.97
15	Indiana	15,000.00	9,000.00	25,000.00			
16	Iowa	15,000.00	9,000.00	22,750.00		15.00	11,063.82
17	Kansas	15,000.00	9,000.00	[e] 32,000.00		10,318.35	7,020.31
18	Kentucky	15,000.00	9,000.00			39,487.61	9,609.49
19	Louisiana	15,000.00	9,000.00	10,000.00		12,500.00	3,619.25
20	Maine	15,000.00	9,000.00				
21	Maryland	15,000.00	9,000.00	20,500.00			5,766.59
22	Massachusetts	15,000.00	9,000.00	13,500.00		5,165.00	2,732.07
23	Michigan	15,000.00	9,000.00	30,500.00		3,215.00	[f] 2,313.94
24	Minnesota	15,000.00	9,000.00	[f] 62,440.83			[f] 12,966.11
25	Mississippi	15,000.00	9,000.00	[e] 30,075.00			[f] 15,473.07
26	Missouri (College)	15,000.00	9,000.00	16,695.45		5,262.83	9,548.75
27	Missouri (Fruit)			[g] 40,700.00			
28	Montana	15,000.00	9,000.00	10,886.58	9,486.31		7,138.08
29	Nebraska	15,000.00	9,000.00	[h] 15,000.00			23,711.80
30	Nevada	15,000.00	9,000.00		388.55		248.05
31	New Hampshire	15,000.00	9,000.00			1,616.96	377.50
32	New Jersey (State)			[i] 45,000.00			
33	New Jersey (College)	15,000.00	9,000.00				
34	New Mexico	15,000.00	9,000.00			77.75	3,922.29
35	New York (State)	1,500.00	900.00	86,595.63			
36	New York (Cornell)	13,500.00	8,100.00				
37	North Carolina (College)	15,000.00	9,000.00				1,073.41
38	North Carolina (State)					55,380.00	5,000.00
39	North Dakota	15 000.00	9 000.00	8,000.00	500.00		3,236.10
40	Ohio	15,000.00	9,000.00	84,000.00			8,470.22
41	Oklahoma	15,000.00	9,000.00	718.80			
42	Oregon	15,000.00	9,000.00				2,584.48
43	Pennsylvania	15,000.00	9,000.00	[k] 4,000.00			7,794.21
44	Rhode Island	15,000.00	9,000.00				
45	South Carolina	15,000.00	9,000.00				1,717.80
46	South Dakota	15,000.00	9,000.00				
47	Tennessee	15,000.00	9,000.00			1,000.00	7,445.41
48	Texas	15,000.00	9,000.00	[e] 7,000.00			
49	Utah	15,000.00	9,000.00	17,563.05			5,065.81
50	Vermont	15,000.00	9,000.00	1,033.10	113.04	2,729.48	
51	Virginia	15,000.00	9,000.00	[l] 5,000.00			625.55
52	Washington	15,000.00	9,000.00				2,059.42
53	West Virginia	15,000.00	9,000.00	10,000.00		9,151.09	6,562.56
54	Wisconsin	15,000.00	9,000.00	18,500.00		8,843.87	
55	Wyoming	15,000.00	9,000.00				
	Total	720,000.00	432,000.00	947,558.67	22,835.30	186,159.70	210,391.28

[a] Including all balances.
[b] The station also has a State appropriation of $1,745.84 for farmers' institutes.
[c] For biennium ending June 30, 1909.
[d] For biennium ending November 30, 1908.
[e] For substations.
[f] Including substations.
[g] For biennium ending December 1, 1908.

additions to equipment, 1908.

Miscellaneous.[a]	Total.	Additions to equipment.							
		Buildings.	Library.	Apparatus.	Farm implements.	Live stock.	Miscellaneous.	Total.	
$55.72	$37,429.59	$778.00	$635.00	$1,851. 0	$152.00	$18.00	$234.50	$3,668.50	1
1,087.56	4,857.66	....	....	....	200.00	....	350.00	550.00	2
....	1,500.00	....	....	....	75.00	....	115.00	190.00	3
1,150.79	[b] 34,531.41	557.13	83.67	226.21	339.71	161.25	447.90	1,815.87	4
155.73	69,886.14	381.56	349.05	92.81	1,043.14	1,486.95	2,045.31	5,398.82	5
46,284.89	207,520.32	70,644.64	164.15	3,853.25	3,604.39	3,844.25	384.21	82,494.89	6
13,479.58	64,979.58	500.00	298.62	1,129.81	619.15	3,310.53	2,546.20	8,404.31	7
658.85	49,085.25	....	574.38	113.37	182.96	....	462.86	1,333.57	8
761.70	14,561.70	167.39	85.80	533.00	195.91	493.07	....	1,475.17	9
62.50	25,538.09	....	202.26	378.68	504.57	540.70	....	1,626.21	10
170.86	26,935.80	1,826.03	607.37	645.13	413.01	630.00	446.25	4,567.79	11
1,911.67	28,721.14	1,360.62	48.95	769.62	139.09	438.95	....	2,757.23	12
386.68	26,058.06	1,500.00	250.00	2,000.00	350.00	250.00	1,500.00	5,850.00	13
21,201.93	161,132.90	1,568.83	71.86	1,597.54	896.57	6,426.00	....	10,560.80	14
30,959.95	79,959.95	873.69	343.90	459.83	637.42	5,645.77	77,681.74	85,642.35	15
11,612.08	69,440.90	2,629.38	....	972.29	1,172.78	5,560.64	5,519.78	15,854.87	16
8,838.52	82,177.18	2,633.67	28.49	2,043.98	784.17	622.61	637.94	6,750.86	17
12,319.21	85,416.31	12,101.91	856.00	822.36	125.50	....	1,323.13	15,228.90	18
5,161.97	55,281.22	1,951.61	581.45	1,616.53	513.85	1,988.04	....	6,651.48	19
13,822.66	37,822.66	1,508.91	930.20	547.86	122.45	130.00	....	3,239.42	20
502.94	50,769.53	5,599.00	377.55	664.40	363.40	87.50	1,530.74	8,622.59	21
17,295.57	62,692.64	4,000.00	484.00	1,006.16	306.76	373.71	1,299.83	7,470.46	22
2,659.71	62,688.65	500.00	298.01	1,025.58	62.08	....	415.26	2,300.93	23
....	99,406.94	37,000.00	2,000.00	2,101.26	1,917.52	814.25	72,761.33	116,594.36	24
260.69	69,808.76	....	....	....	....	4,500.00	....	4,500.00	25
....	55,507.03	100,000.00	2,750.00	4,500.00	1,750.00	2,500.00	1,200.00	112,700.00	26
....	40,700.00	....	594.38	978.19	989.94	....	1,000.00	2,562.51	27
....	51,510.97	7,000.00	318.00	1,022.00	598.00	1,178.00	200.00	10,316.00	28
5,304.37	[i] 68,016.17	39,700.00	406.80	834.51	3,000.00	50.00	....	43,991.31	29
2,283.57	26,920.17	163.68	136.89	510.11	648.00	906.00	1,238.56	3,603.24	30
....	25,994.46	304.15	659.95	599.97	302.85	598.50	303.16	2,768.58	31
....	45,000.00	....	126.63	564.42	....	....	....	691.05	32
....	24,000.00	80.69	1,513.26	415.70	310.41	390.00	....	2,710.06	33
848.22	28,848.26	2,888.26	11.25	8.65	3,987.96	80.00	....	6,976.12	34
8,324.45	97,320.08	....	1,104.02	160.98	641.35	....	....	1,906.35	35
....	21,600.00	1,600.00	1,000.00	1,260.00	....	....	....	3,860.00	36
636.54	25,709.95	1,076.57	252.29	163.28	194.28	717.00	....	2,403.42	37
....	60,380.00	....	....	....	....	....	....	....	38
8,388.14	44,124.24	10,124.37	76.01	826.97	515.12	1,485.20	690.24	13,717.91	39
40,154.94	156,625.16	899.15	995.04	1,205.84	....	635.00	....	3,735.03	40
2,846.02	27,564.82	472.50	157.06	1,488.46	253.45	655.25	464.69	3,491.41	41
25.47	26,609.95	15,000.00	1,136.48	484.36	149.32	20.00	....	16,790.16	42
....	55,898.10	....	262.00	1,758.00	488.00	872.00	347.00	3,727.00	43
5,286.40	29,286.40	252.83	847.41	265.21	107.39	115.56	491.58	2,079.98	44
1,719.96	27,437.76	650.04	89.23	664.44	388.29	442.00	15.00	2,249.00	45
2,872.63	26,872.63	....	500.00	581.82	423.18	....	....	1,505.00	46
441.41	32,886.82	....	443.56	1,088.92	380.13	330.00	287.97	2,530.58	47
1,185.08	32,185.08	244.30	165.92	274.00	113.75	325.00	95.30	1,218.27	48
3,514.02	50,142.88	473.67	12.32	424.50	680.00	1,800.00	850.00	4,240.49	49
....	27,875.62	1,380.81	169.86	164.16	477.66	527.00	....	2,719.49	50
774.28	30,399.83	496.00	345.78	1,019.41	309.11	480.00	2,104.54	4,754.84	51
....	26,059.42	492.05	48.46	184.40	47.55	....	374.25	1,146.71	52
....	49,713.65	5,572.89	620.91	1,679.38	285.62	344.00	1,562.67	10,065.47	53
....	51,343.87	40,769.36	720.94	522.21	1,162.14	742.29	528.71	44,445.65	54
1,311.59	25,311.59	30,000.00	2,500.00	3,449.00	182.00	2,040.00	....	38,171.00	55
281,102.34	2,800,047.29	407,723.69	26,235.16	51,549.56	33 106.93	54,555.02	181,455.65	754,626.01	

[h] Balance of State appropriation for biennium ending March 31, 1909.
[i] The station also has a State appropriation of $20,000 for farmers' institutes for biennium ending March 31, 1909.
[j] For the fiscal year ended October 31, 1908.
[k] For cooperative tobacco experiments for biennium ending June 1, 1909.
[l] Balance of biennial State appropriation of $10,000.

TABLE 10.—*Expenditures from United States appropriation of March 2,*

	Station.	Amount of appropriation.	Classified expenditures.						
			Salaries.	Labor.	Publications.	Postage and stationery.	Freight and express.	Heat, light, and water.	Chemical supplies.
1	Alabama	$15,000.00	$7,602.14	$1,549.59	$1,402.70	$294.38	$318.04	$363.64	$637.97
2	Arizona	15,000.00	7,151.91	3,007.26	111.47	697.22	370.10	56.59	107.39
3	Arkansas	15,000.00	8,738.39	846.38	1,008.68	273.41	488.92	253.34	262.92
4	California	15,000.00	7,230.99	4,016.57	691.87	601.17	150.71	51.35	91.48
5	Colorado	15,000.00	9,273.16	620.80	3,042.55	337.94	112.20	....	137.80
6	Connecticut (State)	7,500.00	7,500.00	....	....	....	....	....	....
7	Connecticut (Storrs)	7,500.00	5,700.05	943.39	....	122.55	2.85	38.44	56.78
8	Delaware	15,000.00	8,144.07	1,980.45	692.37	189.41	119.54	189.95	146.64
9	Florida	15,000.00	6,498.84	2,281.25	517.75	677.16	456.89	11.50	25.70
10	Georgia	15,000.00	7,435.40	3,183.93	1,304.97	201.78	183.58	302.92	....
11	Idaho	15,000.00	6,517.23	3,286.05	722.57	236.37	312.59	621.18	72.67
12	Illinois	15,000.00	8,306.47	2,199.46	1,845.03	351.90	132.42	120.00	198.84
13	Indiana	15,000.00	9,110.00	4,334.48	503.75	337.14	92.91	15.00	22.20
14	Iowa	15,000.00	9,608.30	....	2,111.92	160.68	270.96	....	474.80
15	Kansas	15,000.00	10,489.27	2,404.05	177.13	96.68	221.80	....	226.24
16	Kentucky	15,000.00	10,628.33	60.98	351.67	419.45	173.82	868.77	310.40
17	Louisiana	15,000.00	14,982.02	....	....	2.98	....	....	....
18	Maine	15,000.00	7,683.40	756.55	259.65	485.65	320.58	548.67	142.76
19	Maryland	15,000.00	8,835.68	2,592.00	5.00	267.27	456.35	615.07	35.55
20	Massachusetts	15,000.00	6,359.88	2,654.09	1,192.88	527.21	164.57	423.19	417.48
21	Michigan	15,000.00	5,696.37	5,259.03	266.90	349.40	238.45	....	265.29
22	Minnesota	15,000.00	8,483.26	....	1,038.44	38.00	....	1,599.92	1.44
23	Mississippi	15,000.00	6,466.08	3,751.40	219.15	250.24	280.10	174.74	14.40
24	Missouri	15,000.00	6,396.48	3,163.09	637.61	217.74	....	35.39	179.57
25	Montana	15,000.00	7,850.00	3,798.25	1,091.23	393.24	218.28	103.04	171.17
26	Nebraska	15,000.00	9,571.95	1,050.08	2,242.95	408.46	27.69	....	68.47
27	Nevada	15,000.00	6,799.29	4,996.60	9.75	141.22	260.52	314.65	298.64
28	New Hampshire	15,000.00	7,620.66	2,543.22	747.52	418.40	147.09	662.58	40.66
29	New Jersey	15,000.00	8,307.50	1,031.76	899.95	959.35	103.57	394.84	247.47
30	New Mexico	15,000.00	6,426.87	2,033.52	553.14	400.80	883.41	238.29	63.57
31	New York (State)	1,500.00	799.21	700.79	....	....	....	....	....
32	New York (Cornell)	13,500.00	6,474.94	1,290.23	2,260.50	375.30	85.92	....	484.31
33	North Carolina	15,000.00	6,945.83	2,624.90	938.54	434.98	258.59	58.79	36.81
34	North Dakota	15,000.00	8,314.68	3,033.69	1,016.26	254.88	76.97	395.25	47.32
35	Ohio	15,000.00	12,550.42	452.23	598.50	19.62	11.91	499.67	27.75
36	Oklahoma	15,000.00	4,426.60	4,793.65	2,056.89	503.86	240.39	113.22	410.93
37	Oregon	15,000.00	8,790.45	3,060.10	793.31	....	67.56	....	33.00
38	Pennsylvania [a]	15,000.00	5,844.48	2,250.95	1,627.69	281.98	1.30	20.00	267.72
39	Rhode Island	15,000.00	8,193.23	1,788.03	121.83	283.49	132.96	612.36	130.83
40	South Carolina	15,000.00	8,078.65	1,391.06	2,262.72	87.61	173.21	16.37	79.72
41	South Dakota	15,000.00	6,394.11	3,212.75	1,283.70	367.83	275.67	1.71	72.36
42	Tennessee	15,000.00	8,580.00	2,408.76	498.81	312.14	97.50	371.58	179.08
43	Texas	15,000.00	6,895.96	1,786.46	1,267.51	332.54	427.92	3.00	79.14
44	Utah	15,000.00	7,778.80	3,561.85	1.45	399.04	12.50	42.13	6.49
45	Vermont	15,000.00	8,554.48	2,456.06	309.81	408.45	59.22	833.86	156.87
46	Virginia	15,000.00	7,791.74	2,392.03	1,229.25	388.67	206.75	121.56	23.63
47	Washington [b]	15,000.00	7,388.88	2,275.70	1,555.67	535.14	130.93	1,051.89	554.30
48	West Virginia	15,000.00	9,014.20	....	233.99	662.85	352.86	771.77	34.50
49	Wisconsin	15,000.00	8,215.00	1,502.16	....	228.50	98.67	27.00	448.07
50	Wyoming	15,000.00	6,552.32	1,483.76	1,509.96	372.78	249.17	721.59	239.27
	Total	720,000.00	388,997.97	106,809.39	43,214.99	16,106.86	9,467.94	13,664.81	8,030.40

[a] Balance, 26 cents.

1887, for the agricultural experiment stations for year ended June 30, 1908.

Classified expenditures.											
Seeds, plants, and sundry supplies.	Fertilizers.	Feeding stuffs.	Library.	Tools, implements, and machinery.	Furniture and fixtures.	Scientific apparatus.	Live stock.	Traveling expenses.	Contingent expenses.	Buildings and repairs.	
$810.03	$624.07	$73.14	$634.85	$132.79	$14.60	$100.37	....	$31.47	$15.00	$395.22	1
516.72	235.92	142.79	55.36	339.71	211.64	108.00	$161.25	1,154.54	15.00	557.13	2
571.37	249.03	239.12	142.55	184.53	253.33	....	723.99	70.22	181.00	512.82	3
516.47	15.00	304.20	25.23	68.48	255.29	17.68	....	925.48	19.00	19.03	4
148.58	....	....	165.86	2.75	553.60	49.97	....	489.79	15.00	50.00	5
....	....	....	....	....	....	....	....	....	....	....	6
172.86	12.00	17.20	56.34	16.82	201.00	9.00	.93	118.27	15.00	16.52	7
497.66	314.93	328.52	184.45	493.05	29.13	58.25	466.70	448.03	180.74	536.11	8
483.66	102.67	1,483.62	280.64	388.42	357.25	....	630.00	283.73	15.00	505.92	9
430.10	362.27	659.18	10.50	101.70	....	8.98	211.78	93.79	15.00	494.12	10
1,094.10	....	475.90	155.61	74.50	149.32	....	249.53	291.70	15.00	725.68	11
407.95	11.00	226.70	71.86	146.73	118.94	335.76	....	511.94	15.00	....	12
263.88	....	....	133.83	26.55	....	....	....	160.26	....	....	13
167.77	....	....	....	368.56	16.00	105.35	1,700.66	....	15.00	....	14
379.87	136.00	....	15.45	174.50	15.75	324.15	105.00	197.10	....	37.01	15
371.81	....	....	746.38	128.25	397.00	420.39	....	67.23	15.00	40.52	16
....	....	....	....	....	....	....	....	....	15.00	....	17
380.75	....	1,576.87	467.94	110.86	569.89	341.07	96.92	481.63	28.50	748.31	18
147.38	52.69	604.11	114.31	301.25	210.54	128.97	85.00	418.06	15.00	115.77	19
531.33	383.72	732.97	249.38	155.42	70.27	299.41	324.20	160.28	15.00	338.72	20
890.91	....	267.27	685.40	246.93	69.28	312.76	....	308.78	5.88	137.35	21
360.86	....	2,082.49	....	398.96	123.11	82.08	416.25	108.29	....	266.90	22
621.92	7.05	1,378.24	26.60	584.66	....	2.67	622.45	238.43	15.00	346.87	23
915.06	7.20	2,739.46	28.25	62.56	64.75	53.85	218.87	265.12	15.00	....	24
349.82	....	....	305.00	122.02	196.89	39.71	30.00	264.85	15.00	51.50	25
112.51	....	939.69	....	86.50	181.00	217.96	....	77.74	15.00	....	26
810.84	....	112.50	98.44	62.75	251.07	250.00	6.00	386.55	37.50	163.68	27
615.53	138.75	41.01	664.60	133.40	303.16	176.15	....	498.49	15.00	233.78	28
295.09	194.65	58.60	975.98	115.41	390.92	159.17	390.00	331.05	64.00	80.69	29
510.47	258.00	1,937.66	....	235.27	125.74	....	80.00	250.76	252.50	750.00	30
....	....	....	....	....	....	....	....	....	....	....	31
457.89	12.75	....	171.67	3.00	133.75	871.33	200.00	70.47	....	607.94	32
445.97	218.10	733.04	109.00	350.86	566.30	1.23	457.00	467.05	15.00	338.01	33
438.19	....	764.86	72.51	303.32	28.75	67.66	....	48.29	15.00	122.37	34
195.06	....	....	....	99.06	....	....	....	55.41	19.62	470.75	35
712.00	62.26	492.03	155.06	91.60	302.32	173.70	402.20	40.79	15.00	7.50	36
627.32	....	676.54	578.45	149.32	....	....	20.00	188.95	15.00	....	37
398.81	186.48	2,403.53	234.35	233.26	8.00	398.08	382.84	166.23	39.41	254.63	38
370.37	165.86	839.82	718.63	230.75	489.08	158.76	....	192.95	15.00	556.05	39
444.58	438.93	784.00	89.23	199.04	16.15	....	408.00	50.06	15.00	465.67	40
513.91	....	1,025.48	372.02	116.80	464.20	294.77	380.50	185.93	38.26	....	41
183.47	39.81	1,361.64	198.42	7.60	244.75	51.20	....	75.80	15.00	374.44	42
326.69	83.56	1,810.62	154.86	....	101.88	....	1,182.00	349.32	98.75	99.79	43
207.18	....	1,193.03	2.50	125.48	66.05	39.80	479.45	499.95	28.20	556.10	44
120.15	95.83	162.61	164.86	178.60	202.32	55.32	....	476.56	15.00	750.00	45
872.78	41.63	....	279.69	184.40	709.23	86.20	152.00	485.44	35.00	....	46
460.13	....	....	34.21	47.55	374.25	98.50	....	162.55	15.00	42.05	47
196.02	2.25	1,282.80	382.01	34.00	318.81	56.65	....	643.55	341.00	672.74	48
698.83	35.79	593.75	595.29	759.93	65.00	363.97	191.51	478.90	15.00	682.63	49
786.86	....	1,662.03	41.20	194.92	193.14	51.63	259.00	297.83	15.00	369.54	50
21,831.51	4,488.20	32,207.02	10,648.77	8,572.82	9,413.45	6,370.50	11,034.03	13,569.61	1,804.36	13,493.86	

[b] Balance, $273.25.

TABLE 11.—*Expenditures from United States appropriation of March 16,*

	Station.	Amount of appropriation.	Classified expenditures.						
			Salaries.	Labor.	Postage and stationery.	Freight and express.	Heat, light, and water.	Chemical supplies.	Seeds, plants, and sundry supplies.
1	Alabama	$9,000.00	$5,565.84	$538.33	$84.07	$81.84	$28.60	$40.39	$477.30
2	Arizona	9,000.00	8,517.71	4.50	....	3.40	....	250.57	.75
3	Arkansas	9,000.00	6,158.34	139.05	44.21	74.94	....	337.24	108.37
4	California	9,000.00	3,964.72	1,225.45	7.31	116.14	12.00	493.03	167.87
5	Colorado	9,000.00	5,749.78	5.45	9.32	107.58	120.64	175.35	103.17
6	Connecticut (State)	4,500.00	1,750.00	1,430.85	40.71	25.57	282.82	430.54	141.99
7	Connecticut (Storrs)	4,500.00	2,691.60	196.08	26.20	....	....	328.74	543.24
8	Delaware	9,000.00	7,122.68	183.41	.25	28.52	....	453.26	179.76
9	Florida	9,000.00	6,713.74	45.60	8.69	202.69	30.32	544.41	405.65
10	Georgia	9,000.00	5,743.64	947.43	108.33	42.07	91.97	....	425.08
11	Idaho	9,000.00	2,800.00	1,699.91	70.14	119.21	152.25	182.78	928.22
12	Illinois	9,000.00	4,502.25	1,267.60	11.00	86.03	....	442.09	147.47
13	Indiana	9,000.00	7,029.96	350.20	14.32	44.70	....	60.00	168.70
14	Iowa	9,000.00	3,945.00	1,027.97	150.84	128.08	....	195.84	336.33
15	Kansas	9,000.00	4,398.36	2,602.03	34.92	38.94	40.41	238.34	206.66
16	Kentucky	9,000.00	8,569.79	....	2.00	....	....	....	26.89
17	Louisiana	9,000.00	7,045.15	99.84	1.80	54.33	164.60	634.82	14.80
18	Maine	9,000.00	6,406.24	7.50	26.40	30.58	30.50	15.05	1,036.62
19	Maryland	9,000.00	5,251.31	970.20	9.95	....	113.54	426.50	106.53
20	Massachusetts	9,000.00	7,121.81	932.68	23.45	4.70	....	11.48	17.50
21	Michigan	9,000.00	4,902.90	1,364.72	1.62	139.90	....	38.38	457.19
22	Minnesota	9,000.00	3,595.56	3,028.92	15.00	11.35	128.69	11.40	203.14
23	Mississippi	9,000.00	1,640.61	813.90	33.57	235.47	201.00	18.72	59.50
24	Missouri	9,000.00	883.33	2,220.37	1.10	400.00	....	108.32	363.61
25	Montana	9,000.00	5,200.00	1,284.38	14.25	108.47	....	351.99	451.97
26	Nebraska	9,000.00	7,232.70	255.76	18.75	48.50	....	266.50	270.10
27	Nevada	9,000.00	7,626.16	138.45	82.35	20.70	....	324.03	127.80
28	New Hampshire	9,000.00	5,516.88	1,053.21	....	34.30	....	92.82	293.76
29	New Jersey	9,000.00	6,680.00	436.47	....	23.02	....	9.15	465.19
30	New Mexico	9,000.00	3,424.76	863.14	105.32	684.01	3.30	43.60	148.44
31	New York (State)	900.00	900.00	....	....	....	....	....	....
32	New York (Cornell)	8,100.00	5,933.26	714.73	73.43	86.66	....	108.10	288.90
33	North Carolina	9,000.00	6,780.00	508.57	....	....	....	406.94	367.91
34	North Dakota	9,000.00	6,333.32	1,184.80	....	61.44	....	49.55	731.49
35	Ohio	9,000.00	6,621.40	73.10	1.82	32.69	....	185.71	448.53
36	Oklahoma	9,000.00	2,385.07	2,562.23	46.94	49.34	70.88	110.40	379.43
37	Oregon	9,000.00	4,149.90	2,193.61	....	34.24	....	9.56	435.94
38	Pennsylvania	9,000.00	5,395.47	556.50	52.97	....	218.60	368.45	129.08
39	Rhode Island	9,000.00	5,919.27	1,096.57	11.44	61.85	477.72	120.71	207.72
40	South Carolina	9,000.00	4,441.42	1,285.99	52.02	14.40	....	119.77	72.65
41	South Dakota	9,000.00	3,330.07	3,464.42	8.00	88.80	40.01	907.29	359.51
42	Tennessee	9,000.00	6,020.00	680.16	13.90	201.72	90.84	190.34	221.62
43	Texas	9,000.00	4,209.83	1,069.93	106.09	217.50	232.54	1,027.00	513.48
44	Utah	9,000.00	4,830.20	2,306.45	77.05	.35	350.71	320.62	194.24
45	Vermont	9,000.00	3,867.52	1,976.85	35.64	47.64	141.13	135.86	139.55
46	Virginia	9,000.00	3,785.04	331.19	....	142.11	133.73	1,118.76	1,407.62
47	Washington	9,000.00	6,771.53	666.18	17.50	108.10	....	342.65	137.04
48	West Virginia	9,000.00	6,822.49	....	15.61	....	....	20.87	212.13
49	Wisconsin	9,000.00	4,017.00	2,233.00	....	....	54.00	114.29	893.94
50	Wyoming	9,000.00	4,473.81	333.53	30.65	175.87	94.04	328.94	66.54
	Total	432,000.00	254,737.42	48,371.21	1,488.93	4,217.75	3,304.84	12,511.15	15,590.92

1906, for the agricultural experiment stations for year ended June 30, 1908.

Classified expenditures.											
Fertilizers.	Feeding stuffs.	Library.	Tools, implements, and machinery.	Furniture and fixtures.	Scientific apparatus.	Live stock.	Traveling expenses.	Contingent expenses.	Buildings and repairs.	Balances.	
$30.20	$97.90	$26.44	$1.60	$60.50	$1,288.06	$18.60	$345.59	....	$314.74	....	1
....	....	28.31	76.55	....	118.21	....	....	....	....	....	2
....	1,279.86	123.90	4.61	79.20	92.81	104.96	21.73	....	430.78	....	3
21.07	516.99	23.20	59.25	128.92	951.60	79.75	1,081.63	$21.50	129.57	....	4
....	....	25.53	246.78	555.35	942.25	15.80	493.00	....	450.00	....	5
167.67	....	....	....	107.04	....	....	122.81	....	....	....	6
....	....	70.59	10.80	35.00	502.00	....	94.55	....	1.20	....	7
105.05	4.10	19.81	11.52	....	320.43	74.00	46.99	....	450.00	$0.22	8
37.93	....	317.39	8.44	89.00	62.00	....	507.81	....	26.33	....	9
....	374.40	38.45	....	....	760.64	150.00	74.75	....	243.24	....	10
....	....	123.56	1,447.77	....	....	....	38.00	....	374.05	1,064.11	11
....	300.00	....	....	....	100.00	2,050.00	93.56	....	....	....	12
....	21.60	81.35	9.00	....	47.43	339.75	518.28	....	314.71	....	13
....	1,296.94	....	87.20	....	283.73	1,050.00	48.07	....	450.00	....	14
....	184.03	4.00	290.40	18.50	598.66	93.32	4.50	....	246.93	....	15
....	....	....	....	20.25	381.07	....	....	....	....	....	16
....	60.75	246.56	.25	7.00	253.34	100.65	263.90	10.00	42.21	....	17
....	....	388.99	12.10	....	206.79	67.00	401.75	....	370.48	....	18
....	780.48	122.54	182.94	55.78	535.43	2.50	81.30	....	361.00	....	19
357.51	....	....	16.35	30.00	333.54	....	133.95	....	17.03	....	20
....	189.48	51.80	.65	7.20	810.04	516.60	344.25	19.84	155.43	....	21
....	101.18	....	411.43	....	1,222.70	38.00	162.72	....	....	69.91	22
....	2,713.81	2.10	431.16	91.50	97.89	2,017.00	207.57	....	436.20	....	23
....	3,737.92	....	....	73.50	445.60	645.05	60.85	....	60.35	....	24
....	....	18.39	242.93	41.50	680.45	....	494.08	....	111.55	.04	25
....	6.00	6.80	138.80	....	616.55	50.00	45.14	....	44.40	....	26
187.22	80.28	38.45	....	30.00	260.11	....	61.95	22.50	....	....	27
67.28	....	134.53	183.50	....	423.82	598.50	152.70	....	448.70	....	28
126.60	....	537.28	195.00	259.89	256.53	....	10.87	....	....	....	29
....	....	....	3,092.93	134.30	....	....	50.20	....	450.00	....	30
....	....	....	....	....	....	....	....	....	....	....	31
....	....	4.85	....	22.25	389.15	....	89.56	....	389.11	....	32
308.77	....	143.29	....	....	162.05	200.00	122.47	....	....	....	33
17.60	....	....	148.97	205.13	265.70	....	....	....	2.00	....	34
7.25	122.00	417.51	29.15	6.10	538.28	46.89	41.17	....	428.40	....	35
....	778.32	....	161.85	119.37	1,314.76	17.50	244.60	....	445.00	314.31	36
....	....	558.03	....	....	484.86	....	833.86	....	300.00	....	37
527.13	130.97	7.24	127.87	....	1,166.50	....	319.22	....	....	....	38
101.03	481.16	128.78	52.00	2.50	106.45	115.56	112.24	....	5.00	....	39
226.18	1,731.65	....	189.25	5.50	464.95	34.00	9.70	....	352.52	....	40
18.80	153.72	32.70	289.63	....	287.05	20.00	....	....	....	....	41
....	....	245.14	25.87	43.22	1,037.72	....	167.71	....	61.76	....	42
....	234.73	6.06	37.70	....	236.30	105.00	713.30	....	290.54	....	43
....	40.46	5.86	204.29	.75	380.22	....	106.95	....	181.85	....	44
....	2,228.24	2.60	24.45	....	108.84	69.00	61.48	2.22	158.98	....	45
5.50	....	66.18	118.92	35.31	933.21	328.00	96.08	2.35	450.00	46.00	46
....	....	14.25	....	....	15.90	15.00	461.85	....	450.00	....	47
....	283.33	30.39	....	....	1,317.98	....	292.34	4.86	....	....	48
....	1,488.93	....	19.10	....	179.74	....	....	....	....	....	49
....	407.87	....	35.05	56.77	650.40	1,840.75	253.90	....	251.88	....	50
2,312.79	19,827.10	4,092.85	8,626.06	2,321.33	22,631.74	10,803.18	9,888.93	83.27	9,695.94	1,494.59	

TABLE 12.—*Disbursements from the United States Treasury to the States and Territories for agricultural experiment stations under the acts of Congress approved March 2, 1887, and March 16, 1906.*

State or Territory.	Hatch Act.		Adams Act.	
	1888-1907.	1908.	1906-7.	1908.
Alabama	$299,999.34	$15,000.00	$9,019.89	$9,000.00
Arizona	264,803.15	15,000.00	12,000.00	9,000.00
Arkansas	298,163.12	15,000.00	12,000.00	9,000.00
California	300,000.00	15,000.00	11,926.84	9,000.00
Colorado	299,963.24	15,000.00	12,000.00	8,756.22
Connecticut	300,000.00	15,000.00	12,000.00	9,000.00
Dakota (Territory)	56,240.00	....	....	....
Delaware	299,382.87	15,000.00	9,050.34	9,000.00
Florida	299,966.11	15,000.00	11,998.11	8,998.08
Georgia	299,983.55	14,998.00	12,000.00	9,000.00
Idaho	225,000.00	15,000.00	10,182.04	9,000.00
Illinois	300,000.00	15,000.00	12,000.00	8,864.38
Indiana	299,901.19	15,000.00	7,000.00	9,000.00
Iowa	300,000.00	15,000.00	12,000.00	9,000.00
Kansas	300,000.00	15,000.00	12,000.00	9,000.00
Kentucky	299,996.57	15,000.00	12,000.00	9,000.00
Louisiana	300,000.00	15,000.00	12,000.00	9,000.00
Maine	299,999.62	15,000.00	12,000.00	9,000.00
Maryland	299,967.40	15,000.00	11,763.99	9,000.00
Massachusetts	299,617.70	15,000.00	12,000.00	9,000.00
Michigan	300,000.00	14,676.10	8,691.60	8,650.00
Minnesota	300,000.00	15,000.00	12,000.00	8,643.08
Mississippi	300,000.00	15,000.00	12,000.00	9,000.00
Missouri	295,097.24	15,000.00	12,000.00	9,000.00
Montana	210,000.00	15,000.00	9,417.13	8,999.95
Nebraska	299,932.16	15,000.00	12,000.00	9,000.00
Nevada	299,939.32	15,000.00	11,772.94	9,000.00
New Hampshire	300,000.00	15,000.00	12,000.00	9,000.00
New Jersey	299,961.97	15,000.00	12,000.00	9,000.00
New Mexico	264,998.90	15,000.00	12,000.00	9,000.00
New York	299,860.54	15,000.00	11,880.85	9,000.00
North Carolina	300,000.00	15,000.00	12,000.00	9,000.00
North Dakota	257,330.62	15,000.00	12,000.00	9,000.00
Ohio	300,000.00	15,000.00	10,514.02	9,000.00
Oklahoma	239,270.80	15,000.00	7,000.00	9,000.00
Oregon	286,631.82	15,000.00	7,000.00	9,000.00
Pennsylvania	299,967.95	14,999.74	11,995.41	9,000.00
Rhode Island	300,000.00	15,000.00	9,464.20	9,000.00
South Carolina	299,542.15	15,000.00	10,560.12	9,000.00
South Dakota	243,250.00	15,000.00	7,000.00	9,000.00
Tennessee	300,000.00	15,000.00	12,000.00	9,000.00
Texas	300,000.00	15,000.00	9,876.91	9,000.00
Utah	265,000.00	15,000.00	11,821.94	9,000.00
Vermont	300,000.00	15,000.00	12,000.00	9,000.00
Virginia	299,992.57	15,000.00	11,997.95	9,000.00
Washington	240,000.00	15,000.00	8,080.11	9,000.00
West Virginia	299,968.71	15,000.00	9,859.12	9,000.00
Wisconsin	300,000.00	15,000.00	12,000.00	9,000.00
Wyoming	285,000.00	15,000.00	12,000.00	9,000.00
Total	13,928,738.61	719,673.84	527,873.51	430,911.71

PROGRESS IN AGRICULTURAL EDUCATION, 1908.[a]

By Dick J. Crosby.

Specialist in Agricultural Education, Office of Experiment Stations.

ELEVEN YEARS OF PROGRESS.

The progress made in agricultural education in the United States during the past eleven years as a result of popular demand, stimulated by the work of the State agricultural colleges and experiment stations and of this Department, is unprecedented in the history of the world. In 1897, when the present administration of this Department began, all but one of the land-grant colleges were in running order and doing excellent work, but their total income was only $5,000,000; to-day it is $18,000,000. The property of these institutions was then valued at $51,000,000; now it is $106,000,000. Then there were less than 4,000 students in agricultural courses; now there are over 14,000. Ninety of the graduates of these courses in 1907 accepted positions in the agricultural colleges and experiment stations, or in this Department, at salaries ranging from $500 to $1,700 and averaging $948.66. It is stated by presidents of the agricultural and mechanical colleges that of late the graduates of agricultural courses find remunerative employment much more readily than the graduates from engineering courses.

But the most rapid progress has been made in the field of secondary and elementary education in agriculture. In 1897 Minnesota had the only State agricultural high school, and Alabama had just made provision for the last of its nine district agricultural schools. The teaching of agriculture in the public elementary schools was scarcely thought of. To-day there are 15 agricultural high schools of the Minnesota type and 40 other agricultural high schools receiving State aid, 16 privately endowed colleges and high schools giving instruction in agriculture, 115 State and county normal schools preparing young people to teach agriculture, and, on our lists, over 250 public and private high schools and academies giving some instruction in agriculture. There are 16 institutions offering correspondence and

[a] In previous reviews of the progress of agricultural education it has been customary to record events occurring up to the close of the calendar year. It now seems advisable to make the time covered by this review conform to that of the remainder of the Report of the Office of the Experiment Stations; hence the present review of progress will cover only six months, from January 1, 1908, to June 30, 1908.

reading courses in agriculture, and 26 private or special elementary agricultural schools.

The National Education Association has organized a department of rural and agricultural education, and has a standing committee investigating the desirability and feasibility of teaching agriculture in rural schools. The constitution of the new State of Oklahoma requires the teaching of agriculture in all its public schools, and the legislature of the State has provided for 4 State normal schools with departments of agriculture, and an agricultural high school in each judicial district of the State. The legislature of Virginia has appropriated $20,000 for instruction in agriculture, home economics, and mechanic arts in 10 district agricultural high schools, and Michigan and Mississippi have made provisions for county agricultural high schools.

In 13 States the teaching of agriculture in the rural schools is now required by law. It is encouraged by State and county school officers, and taught in some of the rural schools of 31 other States and Territories. Forty-four States and outlying possessions, then, are making some effort to teach their youth the underlying principles of our greatest productive industry.

Partly as a result of this remarkable growth of sentiment in favor of secondary and elementary instruction in agriculture in public schools, and partly in response to the stimulus given by the Nelson amendment, allowing the land-grant colleges to devote a part of their increased Federal aid to " the special preparation of instructors for teaching the elements of agriculture and the mechanic arts," about half of these institutions now offer training courses for teachers of agriculture, ranging from summer courses of a few weeks to regular four-year courses, with additional graduate work.

EDUCATIONAL WORK OF THE DEPARTMENT OF AGRICULTURE.

This Department has aided materially in promoting the rapid development of agricultural education in the different States and Territories. In this work the Department has been represented primarily by the Office of Experiment Stations, but all of the other Bureaus and Divisions have aided in the work through their investigations and through active cooperation with the educational agencies in the different States and Territories.

The Weather Bureau is endeavoring to aid in eradicating the superstitions everywhere prevailing with regard to the weather, and with this object in view encourages its officials to give popular lectures and when practicable to offer systematic courses of instruction. During the past year numerous courses for the benefit of high schools have been given and regular courses of instruction at agricultural colleges and other collegiate institutions have been offered in Cali-

fornia, Connecticut, Illinois, Maryland, Missouri, New York, North Carolina, Ohio, Vermont, Washington, and Wisconsin.

Popular instruction has also been given at expositions by means of exhibits and lectures, and the department of education of the State of New York has introduced as a part of its "visual education" scheme a popular lecture on meteorology prepared by Mr. J. R. Weeks, of Binghamton, N. Y. This lecture, with the accompanying slides, is loaned for repetition before any school or academy. The Weather Bureau has also given attention during the year to the improvement of the literature of meteorology for students and investigators, through the translation of special technical articles on the Mechanics of the Atmosphere, the revision of the Smithsonian Meteorological Tables, the amplification of the Handbook of Laboratory Experiments, and the supplementing of a collection of problems for advanced students of the physics of the atmosphere, published in the Monthly Weather Review for December, 1906.

The school-garden work of the Bureau of Plant Industry has been continued as heretofore, the experimental gardens on the Department grounds being under the immediate charge of Miss Susan B. Sipe, teacher of botany in Normal School No. 1. As collaborator of the Bureau, Miss Sipe has submitted a report on nature study in English schools in which she sets forth the result of studies made on a trip to England in 1907. This report has been published by the Office of Experiment Stations.[a]

Concerning the distribution of seeds for school-garden purposes, the Chief of the Bureau of Plant Industry reports as follows:

Owing to the fact that the number of requests for seeds for school gardens increased 33 per cent over the previous year, while the allotment of seed for the purpose remained constant, the apportionment of seed to each school was correspondingly less. It is unfortunate that the number of requests honored does not indicate the number of schools receiving the seeds. About 1,400 requests have been honored, but in many instances these were from superintendents or supervisors who requested seeds for all the schools under their control, so that it is safe to say that at least three times as many schools received seeds as there were requests honored. On this basis the seeds at our disposal were sufficient only to allow nine or ten individual gardens to each of the schools desiring them. The increase in the number of requests received for seeds for school gardens may be taken as a true index of the growing popularity of this character of instruction in our common schools. The distribution this year has been chiefly confined to sets of flower and vegetable seeds for individual gardens. In addition, however, nearly 5,000 sets of decorative seeds have been used, besides 2,000 collections of economic seeds. The distribution of economic seeds for school-garden purposes was an innovation this season. The plan is to place in the hands of teachers samples of seed of the important grasses, cereals, and fiber and forage plants in order that students of one locality may become acquainted with the plants which are staple crops not only in their own locality, but in the other important crop areas of the United States. The

[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 204.

quantity of seed of each variety was small, but sufficient to enable at least 1 square rod of the crop to be grown. It is believed that the growing of this illustrative material will add an important feature to the individual work in the school garden. The economic set sent out this year consisted of the following: American upland cotton, broom corn, buckwheat, corn, flax, hemp, Kafir corn, millet, peanut, spring barley, spring oats, spring rye, alsike clover, red clover, white clover, Kentucky bluegrass, and timothy.

The Office of Public Roads has adopted a scheme of appointing engineer students, who devote a part of their time to the work of the Office and are also given definite instruction in highway engineering. During the last fiscal year 5 engineer students were appointed for service, and of these 3 are now junior assistant engineers in the Office of Public Roads, and 2 have taken up college work as instructors in highway engineering. The Chief of the Office of Public Roads makes the following statement concerning the course for engineer students:

On January 20, 1908, a definite course of theoretical and practical instruction for the engineer students in Washington began, covering a period of eight weeks. The time was divided between lectures and laboratory work, as follows:

Monday.—Themes and problems in road construction, history and development of road building, testing laboratory.

Tuesday.—Testing laboratory, petrography and mineralogy, road legislation and administration.

Wednesday.—Field work.

Thursday.—Dust preventives, platting, field notes, estimates, field work, and problems.

Friday.—Petrography and mineralogy, road legislation and administration, clays, asphalts, bitumens and cements, laboratory work.

Saturday.—Library, general geology, quarrying and selection of road materials, testing laboratory.

The plan worked very well and did not in any way interfere with the regular projects of the Office, for the reason that the course was so timed as to be in operation during a period when field work was very much restricted. In addition to the students, those engineers who found it convenient to do so took advantage of the opportunity to receive this instruction. The students were also required to prepare a thesis on some phase of road construction, maintenance, or administration and to enter into discussions on practical topics. Courses of reading were prescribed, embracing the best works on the history of road building, road legislation, administration, economics, construction and maintenance, dust preventives, clays, asphalts, bitumens, cements, and certain other subjects of a miscellaneous character.

The use of Department publications in educational institutions to supplement regular text-books and to serve for reference purposes is growing rapidly. Every year many new institutions are added to the list of those who find much in the Department publications to interest and instruct their students. During the past year 1,522 publications were issued by this Department, of which 447 were new and 998 reprints. These publications comprised 58,510 printed pages and the total number of copies aggregated 16,875,516, an increase of 128,606 over last year.

EDUCATIONAL WORK OF THE OFFICE OF EXPERIMENT STATIONS.

The educational work of the Office of Experiment Stations during the period covered by this report (January to June, 1908, inclusive) was continued under the same general arrangement and with the same appropriation as in the preceding year, one section dealing with agricultural colleges and schools and the other with farmers' institutes and other forms of extension work in agriculture.

The work of the Office relating to agricultural colleges and schools included, as formerly, four general classes: (1) The collection and publication of information regarding the progress of agricultural education at home and abroad; (2) studies of different grades of American and foreign schools in which agriculture is taught; (3) work in cooperation with the Association of American Agricultural Colleges and Experiment Stations and other important associations dealing with educational matters; and (4) the giving of aid to agricultural colleges and schools and to State and local school authorities along lines of agricultural education.

RELATION TO AMERICAN INSTITUTIONS.

The department of agricultural education in the Experiment Station Record has contained numerous abstracts and notes and occasional editorials relating to this subject. The preparation of these involved the examination regularly of many educational publications both American and foreign. The foreign publications, as formerly, were reviewed by Miss M. T. Spethmann, who has also, as formerly, had charge of the preparation of the annual statistics and organization lists of the agricultural colleges and experiment stations.

There has also been published a bulletin entitled, "Simple Exercises Illustrating Some Applications of Chemistry to Agriculture." The publications submitted to the printer but not yet published include a Yearbook article on Training Courses for Teachers of Agriculture, and a review of Progress in Agricultural Education in 1907. The list of institutions in the United States offering courses in agriculture has been revised, and shows a gratifying increase in the number of such institutions, especially in normal schools and other secondary schools for white students. In the original list, issued in February, 1907, there were 30 normal schools teaching agriculture as compared with 115 State and county normal schools at the time of revision, and 105 other secondary schools as compared with 320 now, including 15 agricultural high schools connected with colleges. The total number of institutions listed for whites and negroes has increased from 211 to 535.

Studies of American and foreign schools in which agriculture is taught have been carried on in connection with the editorial and other

work of the Office, and the number of cards in the index of these institutions has been increased to 4,175. Personal observation and study of the work of American colleges and schools of agriculture and of normal schools offering courses in agriculture have been made whenever it has been feasible to do so in connection with the annual inspection of agricultural experiment stations, or on occasions when members of the staff have been called upon to attend important meetings. During this period the Office has had the assistance of a graduate student in Teachers' College of Columbia University as collaborator in making a study of public secondary schools offering courses in agriculture.

The educational work in cooperation with the Association of American Agricultural Colleges and Experiment Stations has been carried on as formerly. The Director of this Office has continued to act as bibliographer of the association and as chairman of the committee of the association on instruction in agriculture, which is now engaged in studying courses in agricultural engineering and in home economics. He has accepted for the third time the position of dean of the Graduate School of Agriculture, which will be in session during July at Cornell University. He has also accepted the chairmanship of a standing committee on horticultural education appointed by the National Council of Horticulture at its meeting in Norfolk in November, 1907, and has attended two meetings of the committee to consider courses in horticulture for elementary and secondary schools. The Director has also taken part in a number of other important educational conferences and has spoken at a number of State meetings and other gatherings of educators.

The Specialist in Agricultural Education has continued to act as secretary of the committee on instruction in agriculture of the Association of American Agricultural Colleges and Experiment Stations, and has aided the committee on industrial education in schools for rural communities of the National Education Association to prepare a report on the teaching of agriculture in secondary schools. To this end he visited schools at Waterford, Pa., and Calvert, Md., and prepared detailed memoranda of their work which were incorporated in the report of the committee as submitted at the annual convention of the association in Cleveland, June 29 to July 3, 1908.

The giving of aid to agricultural colleges and schools and to State and local school officers along agricultural lines continues to draw heavily upon the resources of the Office. The number of public elementary and secondary schools in which agriculture is taught is increasing at an astonishingly rapid rate, and every material increase of this kind is followed by greater demands upon this Office for publications, for assistance in outlining courses of study, or for advice concerning some matter of practice or policy.

In the matter of helping these schools to find competent teachers of agriculture the Office has met with serious difficulties. There are not enough competent teachers to be had. The Office maintains a card directory of over 1,500 teachers and investigators in agriculture, including a supplementary list of those seeking positions, but the latter are few in number and only a small percentage of these are candidates for public-school work. Our directory undergoes a general revision annually, besides being revised in part almost daily. This work is done by Miss M. A. Agnew, who has also been put in charge of recording changes in the organization lists of the colleges and stations and compiling these lists for publication annually.

The demands upon the Office for assistance in outlining and organizing agricultural courses in public and private schools and for addresses at large conventions, lectures at colleges and universities, and other services requiring the absence of our men from headquarters have been greater than in any previous year. Mr. H. O. Sampson returned to us for the month of June and has been engaged during the whole month at a summer school for teachers in Louisiana, his traveling and other expenses being paid by the Louisiana school authorities. He is also engaged for the month of July to teach agriculture in the summer school for teachers at Cape May, N. J.

The Specialist in Agricultural Education has given a course of five lectures to teachers at the summer school of the University of Texas, and will give similar lectures in July at Miami University, University of Tennessee, and the Massachusetts Agricultural College. The titles and contents of these lectures were as follows:

(1) Agriculture defined—as a science and an art; elementary, secondary, and collegiate.

Possibilities and limitations of the subject; relations to nature study in the elementary schools and to botany, chemistry, and physics in the secondary schools.

(2) Supplementing the text-book of agriculture in elementary and secondary schools.

Laboratory exercises, school and home gardens, demonstrations, field trips, excursions, helpful literature.

(3) School agriculture in its relations to the community.

What the school should do for the people of the community and what the people should do for the school.

(4) Boys' and girls' clubs.

Crop-growing contests, sewing and cooking contests, exhibitions and prizes.

(5) Agriculture as it is taught in some public schools.

Illustrated by lantern slides showing features of laboratory and field exercises, school gardens, and school-ground improvement, boys' and girls' club work.

Addresses were given at three department meetings of the National Education Association, at National and State meetings of the Farmers' Institute Workers, at the convention of the Tri-State Grain and Stock Growers' Association in Fargo, at the convention of the American Seed Trade Association in Detroit, at State meetings of teachers, and at several other educational gatherings, besides spending several days in helping to organize boys' corn-growing contests in Michigan.

RELATION TO FOREIGN INSTITUTIONS.

THE INTERNATIONAL INSTITUTE OF AGRICULTURE.

The International Institute of Agriculture, at Rome, is a unique institution. It is in a class by itself. It is not for instruction, as some inquiries would imply, but strictly for investigation, the collection of data, and the prompt dissemination of information of interest to the nations of the earth. It is to deal especially with the economics of agricultural production and distribution, and with the sociological problems of agriculture. Its novel character makes the plans for its development a matter of no small interest.

Credit for the conception of an international institute of agriculture belongs to an American, Mr. David Lubin, of California, who sought the assistance of the King of Italy in carrying the idea into effect. The plan appealed to the King, who issued a call, through the Italian ambassadors, to the different nations of the world for a conference at Rome to consider the advisability of establishing such an international institute. The conference took place in May, 1905, 114 delegates, representing 40 countries, being present. After deliberating something over a week on the matter, the "acte final" was adopted and signed by the delegates present, providing for the establishment of the institute and outlining its constitution and functions. The convention was afterwards ratified by plenipotentiaries of the respective countries. Twenty-five nations, including nearly all of agricultural importance, have joined in the undertaking and pledged their support.

This country has made an appropriation of $4,800 for the payment of its quota toward the support of the institute for the fiscal year 1907, and $8,600 for the salary of a member of the permanent committee and for the expenses of delegates to the general assembly of the institute. The Italian Government is erecting a palace in the gardens of the Villa Borghese in Rome, to serve as headquarters of the institute. This is a handsome two-story building, containing an assembly hall and executive and clerical offices. The first meeting of the permanent committee in charge of the institute was held in the

spring of 1909, and the institute is to be inaugurated and to enter upon active work as soon as possible.

In the meantime the Italian Royal Commission has instigated an inquiry into the exact character and extent of the information which the different countries are in position to supply with regard to their agricultural production. This information will be catalogued and classified, and a report upon it will be ready for the use of the permanent committee when it meets. The systems in operation in various countries for the collection of agricultural statistics are also being studied, in order that the value of these statistics may be properly estimated and means of improvement suggested where desirable.

The functions of the institute are strictly economic and sociological. While its duties have not been worked out in detail, the "acte final" prescribes as among the principal duties that the institute shall collect, study, and publish as promptly as possible statistical, technical, and economic information of interest to agriculturists, excluding "all questions relating to the economic interests, the legislation, and administration of any particular nation." More specifically, the data sought for publication relate to the cultivation of the soil, crop production, trade in and prices of agricultural products on the various markets, wages of rural labor, and the appearance, spread, and means of control of new diseases of plants. It will also give special attention to the subjects of agricultural cooperation, insurance, and credit. It is designed, therefore, to serve as a great intelligence bureau of the countries interested for the dissemination of information relating to agricultural production throughout the world, and many economic and social phases of agriculture.

The finances of the institute are cooperatively provided. The calculated annual expense of the institute is about $175,000. Toward this sum the King of Italy has given the revenues of two domains near Pisa, which amount annually to $60,000. The balance of $115,000 is to be raised among the nations on the basis of units of subscription, which also determine the National representation and voice in the management of the institute. Five groups are recognized. Group 1 carries five votes and sixteen units of subscription; group 2, four votes and eight units; group 3, three votes and four units; group 4, two votes and two units; and group 5, one vote and one unit of subscription. For the first two years a unit of subscription is placed at $300 per annum, and the constitution provides that it can never be more than $500. The subscriptions, therefore, range from $300 to $4,800 per annum. Each nation elects the group it will join in the management and support of the enterprise. The United States has come in on the basis of group 1.

The control of the organization is placed in the hands of a general assembly of delegates sent by the adhering nations and presided over

by an elected president and two vice-presidents. The permanent committee, composed of members designated by the respective governments, is intrusted with the executive management of the institute, under the direction and control of the general assembly. Members of the committee may serve as the representative of one or more nations, but the actual number of members is to be not less than 15. The general secretary will act both for the committee and the assembly.

Thus there is brought into existence a real parliament of the nations, with a permanent cabinet and ministry devoted solely to a consideration of agricultural interests. It is a significant step in international cooperation, and the more so because it is directed toward the greatest of international industries and the one most far-reaching in its sociological influences. It signifies a uniting of forces in peaceful and productive occupations in mutual aid for mutual benefit. As such it is noteworthy as marking another step in the progress of civilization.

AUSTRALIA.

In New South Wales what is known as the "Labour Farm" is maintained at Pitt Town to give instruction to city boys who have a natural bent for country life but who are not in position financially to attend college. The course extends through three months, during which time instruction is given in milking, separating cream, attending to a dairy, feeding cows and pigs, and field work. About seventy boys have been or are going through the course. There is a great demand for the services of these boys among farmers all over the country.

AUSTRIA.

Two new schools giving instruction in meadow culture were opened at Eger and Hohenmauth, in Bohemia, in 1906–7. The course of study in these schools extends over two years with two semesters each year.

A system of itinerant home economics schools is maintained in both the German and Bohemian sections of Moravia. For the German section there is one itinerant instructor in domestic science who holds annually two courses of four months each, which embody practical training in home making and theoretical instruction in domestic science, accounts, correspondence, nursing, etc., and many farm operations, such as the feeding and care of live stock, dairying, etc. Each course accommodates from 12 to 15 pupils who have graduated from the public schools. The localities in which the schools are held are required to furnish a building properly lighted and heated, and the necessary live stock to be used in the instruction.

In the Bohemian section there are two instructors in domestic science, each of whom holds four courses of ten weeks each. These courses are usually held in connection with agricultural winter schools under the direction of the principal of these schools or occasionally in connection with public schools. The course of study in the Bohemian section includes more of theoretical instruction and goes into ethics and the theory of education. An Austrian writer criticises the schools on this account, and thinks that they would be more serviceable if conducted on the plan of the schools in the German section, except that he thinks it an advantage to have the schools conducted under the direction of the principals of fixed schools.

BELGIUM.

The Professional School of Agriculture, which has been located at Chievres, Belgium, since 1903 has been transferred to Ath. It offers theoretical and practical instruction during the months of December, January, and February. A diploma is awarded to pupils who pass the examination at the end of the course. A similar school was opened last year at Braine-le-Comte, and 22 pupils received diplomas at the close of the first course.

BRITISH ISLANDS.

The board of education has issued a special report concerning the work of training courses for teachers of cookery and instruction in cookery given in the public elementary schools. The board has recently decided to discontinue grants to public schools on account of training teachers of domestic science, and hereafter will base all of its grants for domestic-science work upon the number of pupils completing diploma courses.

At Oxford University the chair of agricultural economy has been re-established. The forest gardens and experimental plantations have been largely increased, and the number of forestry students enrolled in 1907 numbered 57. It is proposed to add a lecture theater, a class room, museum, laboratory, and professor's room, in the near future.

Through the generosity of the Worshipful Company of Drapers, which has offered to supplement its previous contributions to the department of agriculture at Cambridge University by an additional grant until 1919 of $1,000 a year, to be used for a second professorship, a chair of agricultural botany has been established. R. H. Biffen has been elected to the position and will continue in connection with it his investigations on the hybridization of wheat and barley.

Studley College, Warwickshire, England, has added to its curriculum a housewife's course, which may be taken either separately

or in conjunction with dairying and poultry keeping, which go to make up the colonial training course. The instruction leads to a certificate and will include training during three terms in cooking, laundering, and housework, together with lectures on sick nursing, first aid, theory of education, and household management.

Mr. T. S. Dymond, in discussing recently the subject of nature study and school gardens, states that he is familiar with elementary education in several continental countries, as well as in Canada and the United States, but "that in none of these does the cultivation of school gardens approach in excellence that in our own country." This statement he later modifies in discussing the nature-study side of gardening wherein "the teaching of gardening operations was as good as it could very well be," but a surprising ignorance was shown by the pupils concerning the principles underlying these operations. Continuing, he says, "In America it is the reverse. There, as practical gardening, it is almost ridiculous; but as training the children to exercise their intelligence about the things that form their surroundings, and thus acquiring a knowledge of those surroundings, natural and industrial, which will be useful to them afterwards in rural life, it is far ahead of ours. The results are better. The boys as they leave school may have less skill and a smaller store of knowledge, but they are more mentally alert, have greater power of adapting themselves to circumstances, are more keen to use any facilities that present themselves for further education."

BRITISH WEST INDIES.

Throughout the British West Indies the Imperial Department of Agriculture continues to give much attention to the development of school gardens and instruction in elementary agriculture in the schools. In Jamaica satisfactory results are reported from the instruction of small landholders by traveling teachers. In this way, and also by the establishment of agricultural banks and prize-holding schemes, the farmers are developing an increased appreciation for improved methods of cultivation.

CANADA.

About the 1st of June, 1907, the Ontario Agricultural College started an experiment in which six graduates of the college were selected to teach agriculture in six high schools of the Province and to serve as agricultural advisers to the farmers in the surrounding country. President Creelman, of the college, recently inspected the work of these instructors and says that each one of them is "busy from early morning until late at night teaching in the school, meeting farmers in the offices down town, writing letters to farmers all over

the country, arranging for short courses of instruction at home or at outside points, preparing plans for experimental plats for the coming summer, attending farmers' institute meetings, and in every possible way putting himself in a position to help the country boy and his father to bigger and higher things in his home life and in his work on the farm." He finds that where there are farm boys in the classes the work is progressing most satisfactorily, and believes that the other activities of the instructors will prove to be of immense value to the farmers and to the teachers in the small rural schools.

The education department of Ontario has recently promulgated a new regulation by which teachers in rural or village schools holding certificates in elementary agriculture from the Ontario Agricultural College receive a special grant of $30 upon completing satisfactory instruction through a school garden. Further plans for the improvement of rural education include the sending of selected teachers from the normal schools to the agricultural college for three months' courses, the inaugurating of short courses for public-school inspectors, the encouraging of conventions of rural-school trustees at the college, and the instructing of high school science teachers in "the practical sciences relating to agriculture."

In the Province of Quebec there are now agricultural schools at Ste. Anne de la Pocatière and Oka, housekeeping schools at Roberval and St. Paschal, a provincial dairy school at St. Hyacinthe, a veterinary school at Montreal, and instruction in horticulture in the elementary schools. The number of pupils in elementary schools receiving voluntary instruction in horticulture increased from 425 in 1906 to 1,258 in 1907.

FRANCE.

The National School of Horticulture, Versaille, France, received 50 new students this year, the largest number since its organization. Owing to its constantly increasing attendance, the minister of agriculture has this year established a course in rural engineering as applied to horticulture, and a course in vegetable pathology.

A recent number of La Semaine Agricole contains a description of the work of an organization founded by Julien Ray, of the University of Lyon, France, for the purpose of providing instruction in agriculture for soldiers and farmers at the garrison in Lyon. In each regiment one lecture a week is delivered by a specialist, who speaks on some phase of one of the following topics: The human body, the soil, the plant, and economic methods of culture. There are also lectures for mechanics. This work was started in 1904, and in the main those attending the lectures have manifested great interest in the work.

GERMANY.

In a number of European countries there is a decided movement toward improving and extending instruction in rural home economics. In West Prussia, for example, there is an organization known as the Association of Rural Home Economics, which has recently opened at Scherpingen, near Sobbowitz, in West Prussia, its fourth school of rural home economics. The course of study extends over one year and will include, in addition to the household subjects, advanced courses in dairying, poultry husbandry, and horticulture. The other three schools established by this association are located at Reifenstein, Obernkirchen, and Maidburg. The two latter of these give training courses to pupils desiring to become teachers of home economics, and the school at Maidburg also offers a course in farm management and advanced courses in dairying, poultry husbandry, and horticulture. Schools similar to these are also found in Baden, Wurttemberg, Bavaria, Hesse-Nassau, Brunswick, Saxony, and Schleswig-Holstein, while in Berlin there is a higher school for the training of teachers for such institutions.

A new horticultural winter school was opened at Elmshorn in 1907 under the direction of Dr. Ludwig Rabe. The school was founded by the Association of Commercial Horticulturists of Germany, and receives additional aid from the State, the District Pomological Society of Pinneberg, and the Chamber of Agriculture of Schleswig-Holstein. It is the first elementary horticultural school to be devoted especially to commercial horticulture. The course will extend through two winter terms—from December 1 to March 1—the first year's work including soils, drawing, surveying, horticultural plant production with special attention to the nursery industry and pomology, forestry, and chemistry in its relation to fertilizers and plant production, while the second year includes in addition fertilizers, bookkeeping, and plant diseases.

Under certain regulations promulgated by the chamber of agriculture, dairies in the Rhine Province are now allowed to offer apprentice work in dairying. In Prussia the ministry of agriculture, domains, and forests encourages the establishment of courses of instruction in forest apprentice schools.

RECOGNITION OF AGRICULTURAL CHEMISTRY IN GERMANY.

The position of agricultural chemistry as a teaching subject in German universities and schools of agriculture has become a matter of apprehension on the part of its followers, and has lately been the subject of discussion in the public press. The chief parties to the discussion have been the Association of German Experiment Stations and the director of the ministry of agriculture, domains, and forests,

Dr. H. Thiel. As the birthplace of agricultural chemistry and until recently the place of its highest development, this discussion and the facts leading up to it are matters of more than local interest, as well as the bearing of the subject on the organization of instruction and experimentation in agriculture.

There has long been a feeling in Germany that agricultural chemistry was not receiving the recognition due to it, and was not maintaining the position it formerly occupied. Of late, it appears, it has not held out such possibilities for a career as to induce young men to enter it. It is thus considered to be on the wane, as a result of the attitude toward it, and this condition is felt to be detrimental alike to agricultural instruction and to the future of agricultural research.

The importance of this matter led to its being made a special topic for discussion at the meeting of the association last winter. On that occasion Prof. Th. Pfeiffer, of Breslau, presented a paper in which he showed the decline of agricultural chemistry in German universities, and maintained that at present it does not occupy a position commensurate with its importance or equal to that of other branches of agricultural science. Of nine universities concerned only two, Königsberg and Breslau, have full (ordinarius)[a] professorships in agricultural chemistry, and four others have only limited professorships, which do not entitle their occupants to a voice in the deliberations of the faculty, and in only a few instances permit them to hold final examinations. Under the German university system this latter provision has considerable influence on the courses elected by students.

The universities of Leipsic, Kiel, and Giessen offer no opportunities for the study of agricultural chemistry under the direction of specialists. In two universities, Göttingen and Halle, full professorships when vacated have been reduced to limited, and in Leipsic, where such men as Knop and Stohmann labored with notable success, agricultural chemistry has been completely dropped. In Kiel, Emmerling was permitted to lecture on agricultural chemistry as a privat docent to the end of his life, and since his death no representative of this specialty has been appointed. It was mentioned, furthermore, that at that university not a single full professorship in any branch of agriculture is provided.

The conditions at the agricultural high schools and academies were said to be somewhat better, although not all that could be wished for, the position and activity of the agricultural chemist often being limited. Professor Pfeiffer stated that at present there is not a single privat docent in agricultural chemistry in all Germany, and hence there are no young men in training for that specialty. This condi-

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[a] In German universities professors are of two grades, ordinarius (full or unlimited) and extraordinarius (limited or subordinate).

tion was ascribed to the present position of agricultural chemistry in Germany, and the small future which it holds out to a man entering it.

From its history this specialty was shown to be a most important pillar of agricultural science, fully entitled to rank among the foremost subjects in agricultural instruction. Unless it can be maintained in its former position, it was predicted that the development of agricultural investigation and agricultural instruction in Germany must surely be retarded. In view of the importance of the matter and the inconsistency of the present attitude, it was decided to petition the German agricultural council for assistance in bringing about increased attention to the teaching of this subject, and in obtaining fuller recognition for it in German universities.

Closely following the above discussion, Dr. H. Thiel, of the ministry of agriculture at Berlin, presented a paper before the International Agricultural Congress at Vienna on the subject of higher instruction in agriculture. In the course of this paper, Doctor Thiel laid down the general proposition that the natural sciences in their applications to agriculture should be taught in the respective departments of these sciences, and not in such departments as agricultural chemistry. He contended that the way should be opened for the agricultural student to learn the principles of natural science on which agriculture rests directly from the general sciences themselves—that is, in those departments of science. This plan, he explained, is ideal at present, and would presuppose the provision in these departments of facilities suited to the special needs of the agricultural student in the form of lectures, laboratories, seminars, and instructors. When these conditions are fulfilled, he maintained that agricultural chemistry, "a bastard made up of the various sciences," can be eliminated from the course of instruction; and he declared that this "stop gap" is out of place except where the needs of the agricultural student are not fully met by the respective branches of natural science.

This characterization of agricultural chemistry and its function was quite naturally resented by the friends of that specialty, not only as being grossly unfair to that subject, which has in so large a measure furnished the basis for agricultural instruction, but as a reversion to an obsolete and impracticable system. The matter was taken up at the meeting of the Association of German Stations in September, 1907, and Thiel was replied to in the public press.

It was contended that if Thiel's characterization was true, Liebig, with a large part of his life work, and a long list of other chemists like Henneberg, Knop, Wolff, Boussingault, Gilbert, and others, are to be regarded as "stop gaps," servants of a "bastard science," which has no place in an ideal curriculum. An army of agricultural chemists, who are carrying on a work of recognized importance in every

country of the civilized world, would be dissolved, and those in whose hands the research in plant and animal nutrition has rested since the time of Liebig would have no place in the institutions of learning.

It was shown that the same contention would apply equally well to all applied science, and that logically all such branches must be stricken from the programme as individual departments of study and be restored to the respective departments of pure science on which they rest. What the agricultural chemists formerly taught would fall to the various branches of natural science—chemistry, botany, zoology, geology, etc. But in these departments the student of agriculture would not find what he needs, for, it was pointed out, at no university have the professors in general science concerned themselves with the special needs of the agricultural student, and these professors already have so broad a field to cover that they must needs restrict their lectures to principles and general facts.

Furthermore, the association laid down the broad principle that it is one thing to know the essential facts of a single branch of natural science and quite another thing to be able to marshal the facts of various sciences and to formulate from them principles which apply to the phenomena of agriculture. Although agricultural chemistry, like all applied sciences, draws its stock in trade from the primary sciences like chemistry, botany, geology, etc., the manner in which it handles these facts makes its methods essentially distinct and gives it an individuality. It is a characteristic and a strength of every applied science, in contradistinction to the primary sciences, that it attempts to work out and master the complex phenomena in the whole range of its field without regard to the limitations of a single science, whereas the primary sciences view the field from a special angle. This point of view is not changed when instruction in chemistry, physiology, botany, etc., is presented to agricultural students with an agricultural color.

The association called attention to the rapid rate at which specialization is taking place within pure as well as applied science, a condition which will continue to increase with the development of science. Agricultural chemistry is, therefore, entirely in accord with the progress of the times, and its retention as one of the special divisions of chemistry is entirely logical.

Doctor Thiel in his reply to the association maintained his contention that the field covered by agricultural chemistry should be assigned to special instructors in the basal sciences, and that when these conditions were met and the agricultural student received thorough and systematic instruction in all the branches of natural science with special reference to agriculture—when he had learned the laboratory methods of chemical, microscopic, physiological, and other lines of work—then the agricultural chemist would have noth-

ing new or important to offer to him; and furthermore, he queried, what possible line of questions the agricultural chemist could put in examination which would not be covered equally well by the teachers of agriculture and the various natural sciences.

Enlarging upon his plan he explained the methods of making field and feeding experiments, of studying the soil, and the like, the student would receive in connection with his study of the special sciences, and he refused to recognize in agricultural chemistry any method or point of view which differs in any way from that of the respective sciences " in whose field its investigations lie."

From the standpoint of teaching, Doctor Thiel holds that the recognition of such specialties as agricultural chemistry brings with it the danger that the agricultural student, especially when he continues his studies for only a short time, will be tempted to restrict the lectures he hears to those in specialties like agricultural chemistry which give him something of the different sciences, rather than to take the more fundamental science courses. This apprehension is undoubtedly well founded, and such a preference seems so natural for a student with limited time that the question arises, Why not? It is, perhaps, one of the strongest arguments for agricultural chemistry that it gives the student an insight into the applications to agriculture of principles of science which would otherwise be closed to him.

This further exposition of Doctor Thiel's views met with equal dissension from the agricultural chemists, whose last reply he has declined to discuss. The disagreement on the essential features of organization for agricultural instruction seems to be complete. Some good may, however, result from the airing which has been given the subject.

Commenting editorially in the Experiment Station Record on the proposal to divide up instruction in the principles of agriculture among the various primary sciences, Dr. E. W. Allen says that it is a reversion to a plan which was long tried abroad as well as in this country, and proved entirely inadequate. The plan is not materially strengthened by the supposition that these various sciences are to be taught in their special relations to agriculture, for the limitations of the various sciences considered individually would still stand in the way. The trouble lies with the attempt to classify agricultural instruction solely on the basis of the fundamental sciences.

A thorough grounding in the natural sciences is confessedly essential to thorough agricultural courses; but so long as the instruction is confined to the departments of pure science it has had and will have very little significance or importance to agriculture. The teaching of the sciences in their relation and applications to agriculture requires a broad outlook and a special point of view, which the teacher of general science rarely, if ever, possesses. It requires sym-

pathetic relations with the various natural sciences, as well as with the practice of agriculture, for the problems are so complicated that they overstep the boundaries of any single primary science.

Agricultural chemistry, like agriculture, is a composite, and it makes use of scientific facts outside the domain of chemistry. It thus calls for broader interests and relationships and for the special ability to marshal the facts of general science and apply them to the solution of agricultural problems. Analyze and separate it into the primary sciences to be taught separately and independently by the various departments and we have destroyed the whole significance and application of this knowledge as far as agriculture is concerned. Either the various departments of science must do just what agricultural chemistry has been doing—lap over into the adjoining sciences and gather data to help explain certain principles and phenomena, or the student must be left to work out these things for himself, an impossible task.

The case is no simpler with investigation. The attempt of the botanist to work out the theory of plant nutrition would at once lead him over into the fields of chemistry and other branches of science, with which he must needs form a combination quite as essentially a "bastard" as Doctor Thiel declares agricultural chemistry to be. It is the complicated character of problems of the soil, of crop production, animal nutrition, dairying, etc., which calls for specialists who are not confined to the limits of a single science, and which has developed special methods of investigation.

If the divisions of science were strictly adhered to we should have no such thing as agricultural science, no systematic attempt to bring together and classify scientific knowledge in its relations to agriculture, and no scientific basis for agricultural instruction. The composite character of agricultural chemistry and its special point of view are the very traits which give it its great usefulness and make its continued recognition extremely desirable from the standpoint of both instruction and investigation. It has blocked out a special field, which with the further classification of agriculture will doubtless need to be more carefully defined but not eliminated.

The classification of agriculture is no easy task, but it is not to be accomplished by reverting to the basis of the primary sciences. This much we have learned from the experience of the past. Any system which refers the instruction in agriculture to the departments of pure science, even with agricultural specialists in those departments, will fail of efficiency on account of the restricted scope and the special view point imposed by the individual departments. The facts of pure science and the conditions of agricultural practice must be brought together and harmonized. This can not be left to the agricultural student or the educated farmer.

The present-day plan for the classification of agricultural knowledge and its formulation into courses of instruction has cut loose entirely from the old academic idea. It is based on the application of this knowledge in the natural divisions of agriculture, rather than on its scientific origin. In a large measure it obliterates for its purpose the boundary lines of pure science. We have long since ceased to teach the subject of soils under the head of geology, and are beginning to group the teaching of the theory and practice of crop production into a department of agronomy. This seems to be a fairly logical and workable basis for the arrangement of teaching courses, and a proposal to return to the former basis of the primary sciences would find scant indorsement among men who have studied the pedagogics of agriculture. It would seem, moreover, to have little support in the courses pursued in other special branches of education.

MANCHURIA.

According to a note in Science, Chum Zen Chan, a graduate of the college of agriculture of the University of California, has been made director of the agricultural experiment station at Mukden, Manchuria. It is also stated that a school of forestry is to be established at Mukden, under the direction of a Japanese expert, but that this institution has not yet been opened owing to lack of funds.

MEXICO.

President Diaz has taken steps to reorganize and develop agricultural education and research in Mexico. He has recently appointed Romulo Escobar to direct the agricultural college and experiment station work in the Republic of Mexico. Escobar was one of the founders and until recently director of the agricultural school at Ciudad Juarez, Chihuahua, which was opened in October, 1905. He is at present reorganizing the National School of Agriculture near Mexico City and plans to inaugurate a modern course of study there, and also to establish other schools in the Republic.

SOUTH AMERICA.

A National Congress of Agriculture, held at Rama, Brazil, to consider means for the improvement of agricultural conditions in that country, has recommended the establishment of a separate department of agriculture, to consist of sections of statistics and rural economy, animal industry, botany, chemistry, agricultural meteorology, microscopy and bacteriology, soils, forestry, pomology, field crops, textile fiber crops, entomology, horticulture, ornithology and game, public roads and transportation, domestic and foreign markets, and publications. The congress also recommended the establishment

of a system of agricultural colleges and experiment stations similar to that in this country, the reorganization of agricultural fairs, the establishment of agricultural banks, a number of cooperative enterprises, and other economic measures.

The director of the Agronomique Institute at São Paulo, Brazil, has established a monthly journal, entitled Boletim do Instituto Agronomico, which is to serve as a monthly record of the work of the institute and will contain data concerning agricultural and meteorological investigations.

The agricultural institutions of Chile now include the Agricultural Institute at Santiago, and the following practical schools: Practical School of Agriculture, Santiago; Practical School of Viticulture and Viniculture, Cauquenes; School of General Agriculture and Animal Industry, Chillan; School of General Agriculture and Forestry, Concepcion; School of Tillage, Animal Breeding, and Agronomy, Ancud; and the Practical School of Agriculture, Temuco.

THE WORK OF THE NATIONAL EDUCATION ASSOCIATION.

During the past two or three years the members of the National Education Association have manifested considerable interest in the subject of agricultural education, and this finally culminated in the organization of a department of rural and agricultural education at the time of the meeting in Washington of the department of superintendence of that association in February, 1908.

The establishment of the new department was authorized by the board of directors of the association at the meeting in Los Angeles in July, 1907. Little more than an organization was effected at the Washington meeting.

The officers elected were E. C. Bishop, Lincoln, Nebr., president; D. B. Johnson, Rockhill, S. C., vice-president; and E. E. Balcomb, Weatherford, Okla., secretary.

The conventions of the department of superintendence are among the most important annual gatherings of educators in the United States. They bring together in large numbers the school officers charged with shaping the policy of the schools and administering their funds, the State and county superintendents of public instruction, presidents of colleges and normal schools, superintendents and supervisors of county and city schools, principals of high schools, teachers, and publishers of text-books. At the Washington meeting nearly 1,600 persons were in attendance, representing every State and Territory except Arizona, Nevada, and Porto Rico. It is a matter of considerable significance, therefore, that this body adopted a resolution declaring its belief "in the great value of the study of agricultural subjects in the schools of the rural districts."

The programme of the Washington meeting was also noteworthy, in that it was given up very largely to agricultural and other features of industrial education.

The Assistant Secretary of Agriculture and the United States Commissioner of Education in their greetings at the opening session referred to the growing interest and importance of agricultural education, and the former gave the principal address at the first evening session, his subject being "Agricultural Industries and Home Economics in the Public Schools." In this address Professor Hays showed the feasibility of providing a unified scheme of instruction in agriculture and home economics, extending from the primary grades through the high school to the agricultural college, and explained the purpose and probable effect of pending legislation for the encouragement by the Federal Government of mechanic arts and home economics in city schools, and agriculture and home economics in agricultural high schools.

On the third day of the convention the forenoon session was devoted to a round table on agricultural education. Dr. A. C. True, of this Office, outlined broadly the educational work of the United States Department of Agriculture. Dr. E. E. Brown, United States Commissioner of Education, in giving some notes on the training of teachers of agriculture, reiterated his conviction that this subject must eventually be taught in practically all schools for country children, and discussed pending legislation for the encouragement by the Federal Government of instruction in agriculture, mechanic arts, and home economics in State normal schools. He pointed out that Federal aid to colleges of agriculture and mechanic arts in the United States had, in his opinion, led to greatly increased local appropriations for those institutions, or at least had not tended to diminish local taxation—a result which had been feared by opponents of Government aid to education.

The training of teachers of agriculture was also discussed by J. R. Kirk, president of the State Normal School at Kirksville, Mo., and K. L. Butterfield, president of the Massachusetts Agricultural College. The latter outlined plans of cooperation between the State agricultural college and one of the State normal schools in Massachusetts for the training of teachers of agriculture.

The Oklahoma plan to introduce agriculture into all the public schools of that State was discussed by the State superintendent of public instruction, Hon. E. D. Cameron. D. J. Crosby, of this Office, read a paper upon "Cooperation between the United States Department of Agriculture and State school authorities to promote agricultural education," in which the present status of cooperation was described and lines of future endeavor were pointed out. This was discussed by E. C. Bishop, deputy State superintendent of public in-

struction of Nebraska, who outlined the Nebraska plan of cooperation between the State department of education and the State university in promoting agricultural education in the public schools.

The papers presented at this round table, and the earnest discussions following each paper, indicated that educators realize that the movement for agricultural education, not only in colleges, but in secondary and elementary schools, is going forward so rapidly that it presents many serious problems to the school authorities in the several States. One of the most troublesome of these problems is to train a sufficient number of teachers for the work in such a way as to give the proper point of view and proper balance to the teaching of this new subject. There was also abundant evidence that the great majority of educators have no clear conception of agriculture as a subject of study, nor of its possibilities and limitations in the public schools.

The convention of the National Education Association in Cleveland, June 29 to July 3, was no less remarkable in the attention given to agriculture than the meeting of the department of superintendence in Washington. As one prominent educator, in writing of the convention, expressed it, "Manual training, domestic science and art, trade, handicraft, and agricultural and technical instruction have dominated the programmes and formed the chief themes of conversation."

The standing committee of the association on industrial education for rural schools submitted its third report, which included special reports by the Specialist in Agricultural Education of this Office and by Supt. O. J. Kern, of Rockford, Ill., on instruction in agriculture as it is now being conducted in four different types of schools. The conclusions of the committee, based upon these special reports and upon their observation of the work being done in one-room rural schools, were to the effect that while examples of successful industrial work in the one-room schools are reported from time to time, this success is due almost entirely to the preparation and personality of the teacher; and that while successful experiments in school gardening, nature study, and elementary agriculture in such schools awaken a general interest in this subject, at the same time they are demonstrating the inadequacy of this work in the district school with one teacher to meet the needs of the children in rural communities. Hence, "the committee can not escape the conviction that adequate facilities for meeting the increasing demand for industrial education must come through schools of secondary type, and that it is easier at the present time to secure this instruction in adequate form in schools which are distinctively organized for the special work. * * * For such schools it is possible to secure appropriations far in excess of what can be secured for the ordinary high school or the consolidated school. This will make it possible to command the

services of better trained teachers and secure better equipment for work. It will dignify the whole subject of industrial education in the estimation of the farming population, and will open up possibilities of utilizing such schools for carrying on this work still further than is done at present."

The department of rural and agricultural education presented its first programme at the Cleveland convention. It held one session in conjunction with the department of technical education, at which a paper by Dr. A. C. True, of this Office, defining agriculture as a science and an art and outlining the field of elementary, secondary, and collegiate institutions in agricultural education, was presented by D. J. Crosby, and discussed by C. F. Curtis and A. B. Storms, of Iowa; J. L. Snyder, of Michigan; and others. One of the regular sessions of the department was devoted to general addresses and discussions on agricultural education, including a paper on "What constitutes successful work in agricultural and rural schools," by B. M. Davis, of Miami University, Oxford, Ohio; an address on "The work of the normal school in preparing teachers to teach agriculture," by H. G. Williams, dean of State Normal College, Athens, Ohio; and an address on "National aid in agricultural education," by Elmer E. Brown, United States Commissioner of Education. Doctor Brown indorsed most emphatically and earnestly the proposition that children should be educated largely in and through the common things about them, the things touching their home interests, and the vocations of their parents—agriculture for children in rural communities. He expressed a belief in the principle of Government aid for education of this sort, but was of the opinion that the means of extending Government aid to education along these lines should be thoroughly investigated before the enactment of additional legislation.

The evening session of the department was devoted to illustrated addresses on school gardening. Opportunity was afforded during the convention to visit the work at the different schools in Cleveland and at the different centers conducted by the Home Gardening Association.

Several other departments of the association devoted space in their programmes to the discussion of different features of agricultural education. The department of normal schools spent most of the time of one session upon the discussion of industrial arts in normal schools. A paper on this subject was read by H. H. Seerley, of Iowa, who confined his discussion largely to the agricultural features of industrial instruction. In the department of manual training Charles H. Morse, secretary of the Massachusetts Commission on Industrial Education, discussed the most urgent educational need of to-day, which, in his opinion, is industrial training in public schools, including agricultural education. In the department of science instruction

one evening was devoted to an address on "Scientific agriculture in the secondary school," by L. H. Bailey, and a paper on "The preservation of the natural resources of the United States," by H. A. Smith, of the Forest Service. The department of Indian education considered several features of industrial training for the Indian, including a paper on "Horticulture and landscape gardening," by R. H. Hoffman, florist at the Indian Industrial School, Carlisle, Pa.

There were also short meetings of several societies whose work is more or less closely related to that of the National Education Association. Among these were the National Committee on Agricultral Education and the American Nature Study Society. The latter discussed at length the training of teachers of nature study.

THE GRADUATE SCHOOL OF AGRICULTURE.

As noted in Progress in Agricultural Education, 1907, arrangements were made to hold the third session of the Graduate School of Agriculture at Cornell University, Ithaca, N. Y., in July, 1908. Director A. C. True, of this Office, as dean of the school has been cooperating actively with the committee on graduate study of the Association of American Agricultural Colleges and Experiment Stations in outlining courses of study and securing a faculty which shall represent the most advanced ideas on all matters relating to agricultural education and research.

THE AGRICULTURAL COLLEGES.

At the end of the fiscal year 1907–8 agricultural colleges were in operation in all the States and Territories except Alaska. By a recent act of the legislature the corporate name of the Agricultural and Mechanical College of Kentucky was changed to State University, and provision was made for the establishment of colleges of law and medicine and for $20,000 additional income annually.

The College of Hawaii has been located at Honolulu and is housed temporarily in two wooden buildings valued at $9,000 and $5,000, respectively. A preparatory course was begun February 3, and a short course, attended by about 50 students, was held February 18 to March 31. John W. Gilmore, of Pennsylvania State College, has been elected president of the college. The formal opening of the college took place September 14, 1908, when four-year courses leading to the degree of B. S. are offered in agriculture, and civil, mechanical, and electrical engineering. Entrance requirements to these courses have been adopted, these being approximately equivalent to a high-school diploma.

In Porto Rico the University of Porto Rico has been designated as the institution to receive the benefits of the Morrill Act of 1890 and

supplementary acts, and the Secretary of the Interior has decided that this institution is entitled to the funds provided for in these acts. The university now includes a normal department and an agricultural department at Rio Piedras. Two departments are in process of organization, viz, an elementary industrial school at Rio Piedras, and a college of agriculture and mechanic arts at Mayaguez, for which the insular legislature has appropriated $40,000.

Including the separate colleges for negroes in the Southern States, there were 64 agricultural colleges in which regular instruction in agriculture was given, and one additional college which conducted a number of farmers' institutes or traveling short courses in agriculture. The number of white students in four-year agricultural courses in 1908 was 4,496, a gain of 758 students, or 17 per cent over the attendance in 1907. There were also 7,293 white students in shorter courses in agriculture and 2,336 negro students in agricultural courses, making a total of 14,125 students enrolled in agricultural courses. This is the largest number ever enrolled in agricultural courses in the United States.

APPROPRIATIONS.

Owing to the fact that not many of the State legislatures met during the winter of 1908, the number of special appropriations for college buildings is relatively small. In Kentucky an appropriation of $200,000 was granted for new buildings and a permanent appropriation of $20,000 for maintenance at the State university, as well as an appropriation of $40,000 for additional buildings and equipment at the Kentucky Normal and Industrial Institute for Colored Persons.

The legislature of Massachusetts has granted the college a deficiency appropriation of $23,600, increased the appropriation for maintenance by $13,000 for the ensuing year, and by $20,000 annually for succeeding years, and appropriated $4,000 for repairing and refitting the station building, $34,000 for the erection and equipment of a horticultural greenhouse and attached building for instruction, $5,000 for additional equipment in the college, and $17,000 for repairs and miscellaneous purposes, making an aggregate of approximately $93,000. The college also received a bequest of $6,000 through the will of Mrs. Louisa S. Baker, late a resident of Amherst, the income of which is to be used to help deserving students.

The Ohio legislature appropriated $240,500 for new buildings at the State university, including a $90,000 veterinary clinic building, $5,000 for the equipment of the agricultural building, and $4,000 for the equipment of the agricultural chemistry laboratory.

The New Jersey legislature has increased the annual appropriation for the support of short courses in agriculture from $6,500 to $11,500,

and has made an appropriation of $50,000 for additional equipment for the short courses.

In Oklahoma an appropriation of $62,000 was made for a domestic science building and girls' dormitory, and $25,000 for a boys' dormitory at the Agricultural and Mechanical College.

BUILDINGS.

Many of the agricultural colleges are erecting expensive and commodious buildings for laboratory and instruction purposes, but comparatively few of these have been completed during the six months covered by this report. The new judging pavilion of the Ohio State University, mentioned in my last report, was dedicated in February with appropriate exercises at which the principal address was made by Dr. T. F. Hunt, of the Pennsylvania State College and Station, formerly dean of the College of Agriculture in Ohio. Dedicatory exercises were also held at the University of Tennessee, May 28, upon the completion of the new $47,000 Morrill Hall (Pl. X, fig. 1). Dean Davenport, of the Illinois University and Station, gave the dedicatory address at these exercises. In connection with the exercises a three-day farmers' convention was held, at which the various agricultural interests of the State were represented. Several sessions were devoted to topics pertaining to agricultural education, in which the East Tennessee Educational Association cooperated.

At the Nebraska School of Agriculture there were completed during the year a boiler house and stack costing $11,250, a woman's building $70,000 (Pl. VIII, fig. 1), a stock and grain judging pavilion $25,800 (Pl. VIII, fig. 2), a veterinary building $13,500, machine sheds $900, and an insectary and pathological greenhouse $3,260. New buildings, costing $28,500, were also completed at the New Hampshire College.

At the Oregon college an agronomy building (Pl. IX, fig. 1) and a fine new dairy barn were erected, the latter consisting of a two-story main building 50 by 100 feet, with two wings each 40 by 80 feet, and one story in height. The building is provided with a milk room, an engine room, a fuel room, and a concrete basement for the storage of roots (Pl. IX, fig. 2). The poultry equipment was augmented by the erection of an incubator house and 28 colony houses.

The Texas Normal and Industrial College for Colored Persons has erected a $5,000 agricultural building, and is putting up a $17,500 dormitory. At the Oklahoma colored college the main building was destroyed by fire, the loss including most of the library and the equipment of the building.

During the year California has expended on buildings more than $780,000, including $53,000 on a creamery, a dairy barn, a stock-

judging pavilion, and workshops on the university farm at Davis. Connecticut has expended $50,000 on a range of greenhouses, a florist's cottage, and a horticultural building. The last is under roof and partly occupied, but can not be completed until another appropriation of about $5,000 is made. The corner stone for a new $50,000 agricultural building was laid at the University of Maine on commencement day, the legislature also appropriating $40,000 for a heating plant to connect all the buildings. The University of Missouri also let the contract for a new agricultural building and cold-storage and ice-making plant, to cost about $100,000.

The new agricultural hall at Iowa State College will be completed about the first of January, 1909. It is now thought that the total cost of this building will be about $380,000. The Montana college has completed a new $80,000 agricultural building, and the Michigan college is erecting an agricultural building which will cost close to $175,000. At the latter institution before the foundation was laid for the new building, much attention was given to moving the farm buildings and arranging them in suitable groups. An illustration of the rearranged group of farm buildings is given in Plate III, figure 1, page 116. At the Georgia college a new agricultural building, to cost $100,000, is nearing completion, and the college farm has been greatly improved by the construction of barns, fences, and other improvements. Wyoming has completed a $25,000 woman's building, which will furnish laboratories and class rooms for the domestic science department as well as dormitory accommodations (Pl. X, fig. 2).

WORK OF THE COLLEGES.

GRADUATE DEPARTMENTS.

The formal opening of the graduate school of the University of Illinois occurred February 4 and 5. It is noteworthy that this graduate school is supported by a special State appropriation of $50,000 annually, and that this is probably the first time in the history of American education that the people in their corporate capacity have put themselves on record as definitely favoring graduate work.

The Bussey Institution established at Jamaica Plain, Mass., in 1870, in accordance with the will of Benjamin Bussey, as a school of agriculture and horticulture of Harvard University, has been closed as an undergraduate institution. In its stead it is planned to maintain an institution for advanced instruction and research in agricultural problems.

The Massachusetts Agricultural College has made formal announcement of the organization of a graduate department, with C. H. Fernald as dean.

FIG. 1.—HOME ECONOMICS BUILDING, NEBRASKA SCHOOL OF AGRICULTURE.

FIG. 2.—STOCK AND GRAIN JUDGING PAVILION, NEBRASKA SCHOOL OF AGRICULTURE.

FIG. 1.—AGRONOMY BUILDING, OREGON AGRICULTURAL COLLEGE.

FIG. 2.—DAIRY BARN, OREGON AGRICULTURAL COLLEGE.

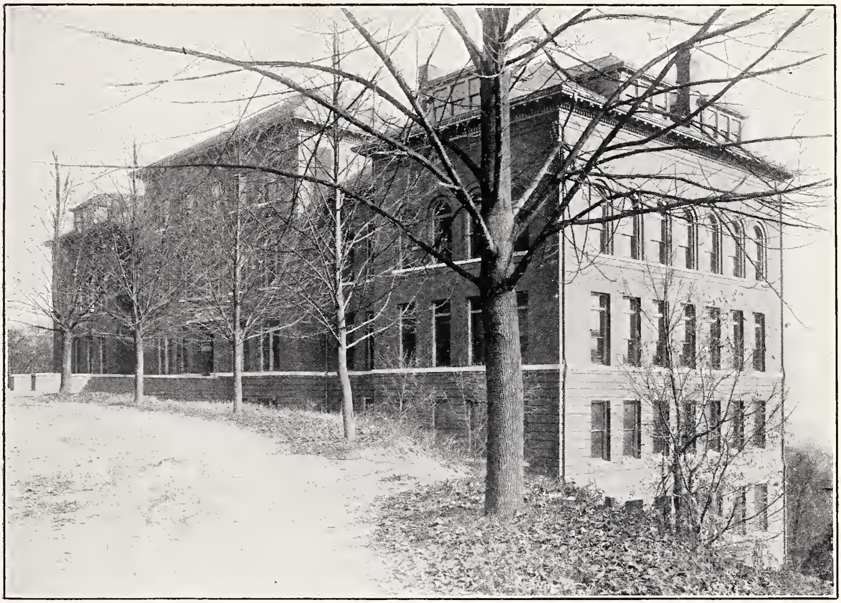

FIG. 1.—MORRILL HALL, THE NEW AGRICULTURAL BUILDING, UNIVERSITY OF TENNESSEE.

FIG. 2.—WOMAN'S HALL, UNIVERSITY OF WYOMING.

REORGANIZATION OF COLLEGE COURSES.

In 1908 quite a number of the agricultural colleges took steps to bring about a more complete differentiation of college and station work or to organize their courses and faculties more effectively. Among these the Alabama Polytechnic Institute established the positions of deans of the faculties of academic departments, engineering and mines, and agricultural science, B. D. Ross being appointed to the position last named.

The Georgia State College of Agriculture has revised its course so as to allow a much larger proportion of elementary instruction in agriculture in the freshman and sophomore years, and has provided groups of electives for the junior and senior years so as to permit the students to take a general course in agriculture or to specialize in agronomy, animal husbandry, horticulture, or agricultural education.

A reorganization of the instruction in agriculture has been effected at the Massachusetts Agricultural College by the establishment of a division of agriculture, to include, for the present, departments of animal husbandry, agronomy, dairying, and farm administration. J. A. Foord, associate professor of agronomy, has been made acting head of this division and professor of farm administration, the duties of the latter position including the management of the college farm. It is the plan eventually to group all the different departments of the college in divisions, which shall be placed under deans. A department of hygiene and physical culture has been established, also an instructorship in agricultural education, the duties of which will include instruction in agriculture at the North Adams State Normal School.

The New York State College of Agriculture is among the first of the colleges to announce definite requirements in farm practice for graduation from the four-year course. While these requirements are pretty definite no university credits are given for farm-practice work performed at the college. This work is considered rather as an entrance requirement which may be disposed of at any time before graduation. Each student must secure not less than 60 points out of a total of 130, 10 points being allowed for experience in each item of the following list:

(1) Harnessing, hitching, and driving horses; (2) plowing and harrowing land and cultivating crops; (3) planting crops (drills, seeders, etc.); (4) harvesting crops (mower, harvester, corn binder, potato digger, etc.); (5) running thrashing machinery, ensilage cutter, wood saw, and feed mill; (6) orchard and fruit yard work; (7) trucking and market-garden work; (8) milking and caring for cows; (9) manufacture of butter and cheese; (10) managing and caring for a flock of sheep; (11) managing and caring for a herd of swine; (12)

managing and caring for a flock of poultry; and (13) any other definite line of agriculture.

This college has also introduced somewhat of an innovation which is designed to afford additional training in public speaking and is known as the "annual agricultural stage." As conducted this year six students delivered competitive orations pertaining to agriculture and student problems. In addition to prizes the winners were given the privilege of addressing the State Experimenters' League and other agricultural organizations at an assembly held during farmers' week.

At the Oregon college the subfreshman year has been abolished and the requirement for admission to all degree courses advanced by an equivalent of one year of high-school work. Two-year industrial courses, admitting students upon completion of the eighth grade of the public schools, were established in agriculture, forestry, commerce, domestic science and art, and mechanic arts. The college was organized into schools of agriculture, engineering and mechanic arts, domestic science and art, and commerce, and an administrative council was established consisting of the president, the director of the experiment station, and the deans of the different schools. There was also established a college council consisting of the president and the heads of all departments. The standard of the degree courses was raised one year, and professorships were established in veterinary science and industrial pedagogy.

In Rhode Island a general readjustment of courses has been made, so that now the following courses are offered: (1) Agriculture, with options in agronomy, horticulture, and animal husbandry; (2) engineering, mechanical, electrical, civil, and chemical; (3) home economics; (4) a teachers' course in applied science, with options in agriculture, chemistry, and biology; (5) two-year courses in agriculture and engineering; (6) a winter course in poultry work; and (7) extension work in agriculture. In connection with the latter work a course of lectures was given in Providence during the winter on "Utilizing the back lot," and in the spring the college furnished an instructor to carry on school-garden work in connection with the public schools of Providence.

A plan of reorganization of the college and station work at Clemson College, S. C., has been adopted by the board of trustees, under which the work of each will be differentiated to a much greater extent than formerly. The instruction force in agriculture in the college will include an entirely distinct corps of men, organized as a director and professor of agriculture, a professor of animal husbandry, a professor of geology and mineralogy, a professor of botany and forestry, a professor of veterinary science who will be in charge

of State inspection work, a professor of horticulture and entomology, an assistant professor of agriculture, and an assistant in veterinary science and the State inspection work. Under this arrangement eight men will devote their entire time to teaching and six men exclusively to station work, with each division in charge of a director. The college has established in its department of textile industry a permanent school of cotton grading. The course extends over six weeks, and is designed for the training of experts in handling and marketing cotton. A number of men have already completed the course and are now engaged under the auspices of the Farmers' Union in assisting farmers to market their crop.

The faculty of Wisconsin University has recently authorized a radical revision of the four-year course in agriculture by introducing agricultural studies into the first two years instead of confining these years to work in general science. A two-year course in agriculture is to be established, to be known as the middle course. The entrance requirements will be the same as for the four-year course, but the student will substitute distinctively agricultural subjects for German and mathematics. The course is designed for high-school graduates desiring a more thorough preparation for farm work than can be secured in the short courses. At least six months' practical farm experience is to be required before the completion of either the two-year or the four-year course. There are also new four-year courses leading to the degree of B. S. and designed to train analytical, industrial, agricultural and soil, sanitary and food, and physiological chemists. The course for the sanitary and food chemist will include work in the bacteriology and biology of water supply, the microscopic examination of foods and drugs, food chemistry, toxicology, physiological chemistry, vegetable histology, and water and gas analysis; and that for the agricultural and soil chemist will consist of work in dairy chemistry, agricultural chemistry, soil chemistry, agricultural bacteriology, physical chemistry, botany, and soil bacteriology.

The Mississippi College for Negroes now offers a four-year agricultural course leading to a degree, and a shorter elementary course which is pursued by most of the pupils.

A school of agriculture has been established in connection with the South Dakota College, and was opened the first Monday in November, 1908. The course extends over three years of five months each, and is intended to prepare young men for life on the farm. Dr. A. A. Brigham, formerly of the Rhode Island College and Station, and more recently connected with the Columbia School of Poultry Culture, Waterville, N. Y., has been elected principal of the school, and Miss Jessie M. Hoover, preceptress.

Two-year secondary courses in agriculture have also been established in connection with the agricultural colleges in Texas and Virginia.

TRAINING OF TEACHERS.

Within the past six months many of the colleges have developed more or less definite plans for the organization of departments of education or for offering some work in agriculture designed especially to aid teachers in presenting this subject in the public schools.

The regents of the University of Nebraska, on February 14, 1908, established a teachers' college which offers the following new courses: A one-year teachers' course in agriculture for high-school and normal-school teachers, a one-year teacher's course in agriculture for grade and rural teachers, a one-year teacher's course in home economics and manual training for women preparing to teach in colleges, and a one-year course in home economics and manual training for women preparing to teach in high schools. In connection with the summer school at the university this year, there was added a new division for teachers in rural schools who receive instruction in agriculture and related subjects under the direction of the principal of the school of agriculture and members of the regular school staff. The university has also announced a correspondence course in nature study to include lessons concerning common trees, seedlings, and elementary plant culture, common seed plants, including weeds, some groups of flowerless plants, domestic animals, common birds, the important groups of insects with the life histories of a few types, the silkworm, toad and frog, soils and their relations to plants and animals, elementary meteorology, nature-study literature, and courses of study for schools. By matriculating regularly in the university, students who complete this correspondence course can secure university credit.

The Michigan Agricultural College has organized a department of agricultural education with W. H. French, former deputy superintendent of public instruction, in charge, and plans have been made to send a graduate of the college to take charge of the high school at North Adams, which through the cooperation of the college and the local school authorities will be conducted for a time at least as a high school offering a strong course in agriculture. A summer school, attended largely by teachers of agriculture in county normal schools, was opened June 29.

At Purdue University a professorship of industrial education has been established, and George L. Roberts, formerly superintendent of schools at Muncie, has been appointed to the position. He will teach pedagogy in relation to industrial education and aid in promoting such education in the State. One reason for this appointment is to enable Purdue University graduates to comply with the State law

requiring teachers in the public schools to have training in pedagogy. Plans for active cooperation with the college of agriculture has been made, and it is expected that much attention will be given to promoting agricultural education in the public schools of the State.

In carrying out the provision of the Oklahoma constitution requiring the teaching of agriculture, horticulture, stock feeding, and domestic science in the common schools, the legislature of that State has designated the Agricultural and Mechanical College as the technical head of the system of agricultural and industrial education and created in that college a chair of agriculture for schools, the occupant of that chair to be a member of the faculty of the college and to direct and advise in all matters relating to the teaching of agriculture and allied subjects in the common schools of the State. He is required to visit the schools, the teachers' institutes, the summer normal schools, and the State normal schools to advise with the teachers and officers concerning improvement of methods of teaching, appliances, the use of seeds, plants, and trees, and to prepare and distribute such leaflets and other literature as may be helpful to teachers and pupils engaged in the agricultural and other industrial work of the schools. E. E. Balcomb, formerly teacher of agriculture in the Southwestern State Normal School at Weatherford, Okla., has been appointed to this chair.

At Minnesota for the first time a short course in agriculture was held June 8 to 27. The school was attended by public-school teachers, county superintendents, and city superintendents—a total of 90 students, who were so enthusiastic over the opportunities thus provided for gaining some knowledge of agriculture that it has been decided to continue the course year after year.

At the Ohio State University a six-weeks' course in agriculture was offered at the summer session, beginning June 22. The subjects taken up included studies in soils, plants, and animals, and the course was so arranged that all the topics could be taken during the session or separately in different years. The complete course is planned to cover a year's work in high-school agriculture, and is intended as a preparation for the teaching of agriculture in elementary and secondary schools. The work of the agricultural extension department of the university is growing rapidly, and the edition of its extension bulletins now runs from 10,000 to 12,000. The department is preparing materials for the illustration of elementary courses in agriculture and distributing them to schools. It has been found in that State that the women teachers in the public schools teach agriculture very successfully when they become thoroughly interested in the subject.

The extension department of the Iowa college finds also that the women teachers of that State can teach elementary agriculture suc-

cessfully. It has held a number of short courses for teachers in different parts of the State. The Illinois college is continuing its efforts to keep in close touch with teachers in high schools and to stimulate the introduction of agriculture in such schools.

Massachusetts has planned to follow its successful summer school of agriculture last year with a similar course this year extending from July 6 to August 14. The first four weeks are planned especially for school teachers and the final two weeks primarily for preachers, with courses in technical agriculture during the entire period, this arrangement affording opportunity for two-week, four-week, or six-week courses. Nineteen courses are offered, including agricultural pedagogy, high-school agriculture, high-school chemistry, soils and tillage, field crops, domestic animals, practical gardening, gardening investigations, trees and shrubs, floriculture, plant life, elementary plant physiology, bird life, insect life, nature-study drawing, and forestry, and lectures on the agricultural industry in New England, agricultural economics, and the social aspect of agriculture, besides field exercises, round-table conferences, and excursions.

Wisconsin also continued its summer school work for teachers of agriculture. The session extended from June 22 to July 31. The Kansas college opened teachers' courses in domestic science and agriculture May 19, the domestic science course continuing for ten weeks and the agricultural course for six weeks. The University of Vermont has announced a summer school for district superintendents to be held during the week of July 13. The Connecticut Agricultural College planned to omit the 1908 session of the summer school, but found that there was such a strong demand for its continuance that the school was announced to open July 1. In Florida over 350 teachers have enrolled for the correspondence course in agriculture. The Pennsylvania State College is taking an active interest in the teaching of agriculture in the secondary and elementary schools and sent two of its men to teach secondary agriculture in two of the summer teachers' institutes.

In North Carolina the Agricultural and Mechanical College held during May, 1908, a drill course for teachers who are required to teach elementary agriculture, for the purpose of affording them drill on the use of the text-book and suggestions concerning other features of instruction in agriculture.

At the Summer School of the South, held annually in connection with the University of Tennessee, greater attention than ever before was given to courses in agriculture for public-school teachers. Scholarships were offered for teachers taking the agricultural courses and it was so arranged that those who enrolled for scholarships were required to take full work in the department of agriculture. About

125 students enrolled for this work and many of these became quite enthusiastic. The plan of requiring the students to take groups of related subjects was found to be so satisfactory in connection with the agricultural work that it will probably be extended to much of the other work in the summer school.

At the summer school of the University of Virginia courses in home economics were offered for the first time, and in agriculture for the second time. The home economic courses were in charge of Miss Edith Charlton, of the Iowa State College, and the agricultural courses in charge of K. C. Davis, dean of the School of Agriculture at St. Lawrence University. Seventy-eight teachers were enrolled in two agricultural courses, one in elementary agriculture, and one in agriculture for high schools. In each course one hour a day was devoted to work in the class room and an average of one hour a day outside of the class room in demonstrations, field trips, etc.

On registration day there were two students who classified in home economic courses, but before the close of the summer school a total of 67 students were taking the work. The home economic courses included both cooking and sewing for teachers in public schools, and it was carried on with such limited equipment as might be supplied at small expense in almost any school. There was also organized a class of over forty housekeepers of Charlottsville who attended lectures and demonstrations arranged especially for them. This class was continued for two weeks.

In addition to the courses in agriculture and home economics there was a course in nature study conducted by Professor Davis, and a course in school gardening conducted by Miss Margaret King. The latter course included daily practical lessons in school gardening.

One of the most striking features of the summer school was the "rural life week," during which there were numerous addresses, stereopticon lectures, and demonstrations by men capable of discussing the various problems of rural life in general and rural-school problems in particular. Among the instructors and lecturers during the week were E. C. Bishop, deputy State superintendent of public instruction in Nebraska; O. J. Kern, county superintendent of schools in Winnebago County, Ill.; Dr. S. A. Knapp, of this Department; Hon. J. D. Eggleston, State superintendent of public instruction in Virginia; T. O. Sandy, of Virginia; Dr. S. C. Mitchell, of Richmond College; E. W. Magruder, State chemist of Virginia; S. W. Fletcher, director of the Virginia Agricultural Experiment Station, and others.

COLLEGE EXTENSION AND SHORT COURSES.

One of the noticeable features of progress has been the continued rapid development of short courses and the various features of extension work, some of which were mentioned under the discussion of

the training of teachers. One of the most elaborate systems of extension is being developed at the University of Wisconsin, where Prof. L. E. Reber has been made director of extension work for the whole university. According to Professor Reber's plan, the work of the university extension division will ultimately reach all classes of people in the State. There will be a central organization reaching out to all parts of the State through lectures, publications, demonstrations, correspondence, various traveling equipments, the services of specialists and traveling teachers, and various monographs, study outlines, and reading and correspondence courses. The State will also be divided into districts in each of which there will be a university representative with assistants. The plan is a very elaborate one and seems to be well designed to greatly extend the influence of the university. Among the features of its agricultural work may be mentioned its efforts to aid in the organization of clubs among farmers for the discussion of topics of the day. Subjects for discussion are furnished, together with outlines of programmes and material for debates. In this work the State board of agriculture, the State bureau of labor and industrial statistics, the State forester, the State library commission, the State experiment association, and all departments of the university and station are cooperating.

In New York the State Agricultural Experimenters' League has arranged for cooperative and demonstration work during the current season by members of the university and station staff in agronomy, plant selection and breeding, horticulture, entomology, animal husbandry, poultry husbandry, dairy industry, plant diseases, soils, and experimental agronomy.

The extension work in Indiana has been organized and actively prosecuted for some time as part of the experiment-station work, supported by State funds, but next year this work will be organized as a division coming between the college and station. The work thus far has been accomplished largely through short courses of a week in different Congressional districts and through educational trains, exhibits at county and State fairs, the organization of boys' corn clubs, county-farm demonstrations, excursions to the university, and lectures at teachers' institutes, Chautauquas, and other organizations. The field demonstrations have been made at three county farms, the commissioners appropriating $100 toward paying expenses and the station paying traveling expenses of its officers. The farmers are invited to come and observe planting, thinning, and harvesting crops, and picnics are held at these farms. Excursions to the university from six counties have occurred during the present season, in some cases as many as 1,200 coming at a time. Corn and stock judging movable schools or short courses held for a week in different Congressional districts are proving popular. The districts are asked to

appropriate $200 each for the expenses of the school. There are now a number of men in the State trained to give instruction in such schools under the station supervision. Two hundred and fifty farmers attended the school in one district last year, and 107 students at a similar school held at the college. Boys' corn clubs have been organized in thirty counties with a membership of about 5,000. Corn is grown and prizes are given for the best crops in the form of scholarship for the short course at the college. Sixty-five boys had such scholarships last winter.

At the West Virginia University a superintendent of agricultural extension has been appointed and considerable attention is being given to the development of short courses, farmers' institutes, traveling schools, and work with teachers who are interested in teaching agriculture in public schools.

"Farmers' week," so called, is one of the newer forms of short-course work undertaken by many of the colleges, and found to be stimulating and helpful to the farmers. In some of the institutions it is a sort of farmers' institute round-up, in others it partakes of the nature of a farmers' congress or conference, while in others it is, more strictly speaking, a short course for adult farmers who come to the college and spend a week or ten days listening to lectures, attending demonstrations, and judging corn and live stock. An enthusiastic farmers' week was held at Pennsylvania State College in January, and was attended by 336 people representing 50 counties of the State. In Indiana the third State corn show and first State fruit show were held at the university in connection with farmers' week, January 13 to 18, 1,100 farmers and their wives being in attendance. In Kansas, where it is called the "annual farmers' institute," the session extended from December 26 to January 4, with courses in judging corn, live stock and poultry, dairy testing, cooking, and sewing. In connection with the institute the various State breeders associations held their meetings. There was also a boys' corn-growing contest participated in by about 400 boys. At the Nebraska School of Agriculture farmers' week was also the occasion for conventions of the different agricultural associations.

A cotton school for farmers was held January 6 to 17 at the Georgia College of Agriculture and about 120 farmers were in attendance. Delaware had a two-weeks' winter course in agriculture with an enrollment of 40 students, which was four times that of any previous year. Summer schools of forestry were held in California under the direction of Findley Burns, of the Forest Service, and in Minnesota, at Itasca State Park, under the direction of Professor Greene.

The educational train is coming to be a regular feature of extension work in nearly all parts of the country, but the Maryland col-

lege is probably the first to purchase a railway car for such work. This car has been fitted up with living quarters for the instruction staff, and a lecture room equipped with a blackboard, stereopticon, and other apparatus. A month's trip during May, with stops of about three days in each place and forenoon and evening sessions of two hours each, brought out a good attendance in most localities.

OTHER FEATURES OF PROGRESS.

In connection with the University of Chicago there has been organized "The Agricultural Guild," the purpose of which is to give practical training in agriculture to meet the needs of three classes: (1) Owners of specialized farms who desire expert advice, efficient farm managers, and a high grade of student labor; (2) young men schooled in the science of agriculture who feel the need of practical training in economics and the management of farms; and (3) boys and young men who desire a practical training in the art of agriculture to fit them to operate farms for themselves or to work as employees on specialized farms.

The university announces that the guild aims to supplement, without duplicating, the work of the agricultural colleges, by giving the practical training which their limited equipment and different purpose prevent them from providing. Its work will be done on 10 farms in the immediate vicinity of Chicago, which will give to graduates of agricultural colleges and others an opportunity to perform all of the operations involved in modern farming, thus doing for them what some large manufacturers and railroad companies are doing for college graduates in engineering.

It is proposed to give a three-year course of training, and to allow students who render efficient service their board, room, washing, and \$15 a month for the first year, \$20 a month for the second year, and \$25 a month for the third year. Students who complete satisfactorily the prescribed work will be awarded a diploma and paid \$200 in money. They may also supplement the practical training by taking courses in the social sciences and in any of the physical or biological sciences relating to agriculture at the University of Chicago or at any other institution.

The guild is governed by a board of advisers consisting of the owners of the several farms, the president of the university, the dean of the faculty of arts, literature, and science, the head of the department of political economy, and the director of the guild, Prof. William Hill. It is hoped eventually to develop it into a school of agriculture of the university.

Among the courses announced for the summer quarter, June 13 to August 28, by the school of education of the University of Chicago, is a course in home economics, including the study of the application

of heat to food materials, chemistry of foods, house sanitation, and the teaching of home economics; and among the subjects to be taught in the natural-science course are nature study in grades, a seminar on the organization of nature study in the grade curriculum, and an elementary study of trees and commercial woods.

THE COLLEGES AT THE INTERNATIONAL LIVE-STOCK EXPOSITION.

The eighth exposition of the International Live-Stock Association, held in Chicago November 30 to December 7, 1907, continued the successes of previous years. The number of exhibits exceeded by 28 per cent the record of the year before, including 1,263 cattle, 665 horses, 375 hogs, and 1,146 sheep, or a total of 3,499 animals, and in most of the classes there was continued improvement in the quality of the entries as well. Seventeen States were represented, and the international scope of the exposition was once more demonstrated by entries from Canada, England, Scotland, and Germany, and the presence of visitors from these and many other foreign countries.

The influence of the agricultural colleges and experiment stations was again strongly in evidence. The list of judges included thirteen members of their staffs. The students were, as in former years, a prominent and distinctive feature, and the exhibits of eleven institutions were distributed through nearly every class of entry.

In the fat-stock division their predominance was especially marked. In the award of prizes in the open competitions, Ohio University again furnished both the champion Berkshire barrow and the grade champion pen of three of all breeds, besides many class prizes. The Iowa college had the champion pen of Poland Chinas, and won several prizes with other breeds, as did also Wisconsin, which received second on dressed carcasses from 100 to 200 pounds in weight. A new feature was the exhibition by Cornell of a pen of Cheshires.

The exhibit of sheep from the Wisconsin University attracted much attention, especially several pens of lambs entered by the station in a comparison of different breeds and rations. At the close of the test the lambs were slaughtered and the carcasses graded. First place in the breed test was awarded to the Southdowns, closely followed by the grade Shropshires. In the feeding test, cracked peas, cracked barley, and cracked corn were compared as supplements to whole oats and bran, and with a ration of whole oats and cracked barley, 1:1, the highest rating being given to the pen receiving cracked peas. Wisconsin was awarded first in a special competition for American-bred Shropshires, with South Dakota second, and several other prizes went to these institutions and to the Missouri University. In the slaughter tests Wisconsin won first and second for 1 to 2 year old wethers, with Iowa third, and was first for lambs with Iowa third.

For cattle, Ohio University won first for calves and the breed championship on Shorthorns, and other prizes went to Kansas, Nebraska, and Iowa. Minnesota won first for 2-year-olds with the Aberdeen-Angus, third for yearlings, second and fourth for calves, and the breed championships both for single steers and herds. The Kansas College won a first for calves, a fourth for 2-year-olds, and seconds for yearlings and herds; Nebraska a first for yearlings and thirds for 2-year-olds and herds; Missouri a third, and Purdue a fifth for calves, and Iowa a fifth for herd.

For Herefords the Minnesota, Nebraska, Purdue, and Missouri universities were among the prize winners. Iowa won third on yearlings with Peerless Wilton 39th's Defender, last year awarded as a calf the grand championship of the show. The Galloway winners were exclusively from the colleges and stations, Missouri receiving first on 2-year-olds and calves, and the championships on single steers and herds, and Ohio first on yearlings, the remaining prizes going to these institutions, Iowa and Nebraska. Ohio also won first in the 2-year-old class and the championship for single steers with the Red Polls.

In the grades and crossbreds the first place for 2-year-olds went to the Colorado college, and Purdue received first for junior yearlings. Purdue, Nebraska, Missouri, and Iowa also received other prizes in this class. The champion herd of the show from all breeds was, as last year, from the Minnesota Station. The grand championship of the show again went to a calf, this time a grade Shorthorn, Roan King, exhibited by James Leask, of Ontario. The second choice was the Angus 2-year-old Andy of the Minnesota Station, which received the same position last year.

In the slaughter tests of fat cattle the Iowa college won a first for 2-year-olds and a second for yearlings. In the former class Ohio University was third and Kansas fourth, and in the latter Nebraska won a third and a fifth.

Two of the stations, Purdue and Missouri, participated in the exhibits of carload lots of cattle. Missouri sent a drove of grade Herefords typical of the stock procurable in that section, and Purdue a load of "short-fed" Herefords fed by a Purdue senior, which received the first premium in its class. Complete data as to kind and cost of feeding and actual profits were available, and the demonstration was regarded as of great value.

With horses the Iowa college was particularly successful, receiving first for light-draft horses in harness, third for aged stallions, first and fourth for aged mares, and fifth for 2-year-olds in Clydesdales, and first and third for aged mares, second for 3-year-olds, and fifth for 2-year-olds in Shires. Ohio won fourth place in Clydesdale yearlings.

In the special classes for college and station stock the competition was keener than ever before. In the cattle classes Minnesota won first on 2-year-olds, cattle 1 to 2 years old, and the championships for a single steer and a pen of five. Colorado was second for 2-year-olds, Kansas third, and Iowa fourth. For calves Ohio was first, followed by Missouri, Iowa, and Kansas; and for cattle, 1 to 2 years old, Kansas was second, Nebraska third, and Purdue fourth. Wisconsin won all the prizes for sheep except first on wether lambs and third on wethers 1 to 2 years old, which went to Iowa. Ohio won third for barrows, the remaining prizes for hogs going to Iowa. For the best general exhibit of five each of cattle, sheep, and hogs, Iowa was first and Ohio second.

The large attendance of students elicited the remark from Breeders' Gazette that "the agricultural college has made the international one of its elective courses." Delegations were on hand from Illinois, Missouri, North Dakota, Cornell, Texas, Ohio, Iowa, Kansas, Wisconsin, South Dakota, Washington, and Ontario, and teams from 10 of these colleges were entered in the various judging contests. The corn-judging trophy, valued at $1,500, was permanently awarded to Iowa, it having won the trophy for three successive years. Iowa also secured permanent possession of the valuable horse-judging trophy, while that for work in judging cattle, sheep, and swine was awarded to Ontario. It is expected that new trophies will be offered for future competitions.

The Armour scholarships contingent upon these contests and the prize winnings of the colleges and stations have been awarded as follows: To Iowa 7, to Missouri 3, to Ohio, Minnesota, Nebraska, and Wisconsin 2 each, and to Purdue and Kansas 1 each. Of the Rosenbaum prizes for the greatest aggregate prize winnings of exhibitors from the respective States, the first prize of $500 was awarded to the Illinois University, the second of $300 to the Iowa college, and the third of $100 to Wisconsin.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.

At a meeting held at the University of Wisconsin in December, 1907, the American Society of Agricultural Engineers, composed of agricultural college instructors engaged in teaching agricultural engineering, was organized and officers were chosen as follows: J. B. Davidson, of the Iowa College, president; F. R. Crane and C. A. Ocock, of Illinois and Wisconsin universities, vice-presidents; L. W. Chase, of Nebraska University, secretary; and W. McE. Nye, of Purdue University, treasurer.

The programme of the meeting dealt largely with the question of instruction in agricultural engineering in the colleges. H. W. Wiley,

of Cornell University, discussed "Courses in agricultural engineering that should be offered," and H. M. Bainer, of the Colorado College, emphasized the need of research and experimental work. Other papers were given by W. Boss, of the Minnesota University, on "Short courses for agricultural students;" P. S. Rose, of the North Dakota College, on "Teaching a course in farm motors;" F. R. Crane, of the Illinois University, on a "Course of rural architecture," and W. G. Hummel, of the Colorado College, on "Agricultural engineering literature." Other speakers included R. P. Teele, who discussed the irrigation and drainage investigations of this Office, and B. B. Clarke, of the American Thresherman.

THE SECONDARY SCHOOLS.

Encouraging progress has been made in the movement for the introduction of agriculture into public secondary schools and for the establishment of agricultural high schools in different parts of the country. Among the States which have enacted legislation on these matters within a few months are Alabama, Michigan, Mississippi, New York, Oklahoma, and Virginia.

One thing which has militated against the rapid introduction of agriculture into high schools has been the attitude of higher institutions with reference to allowing credits for work in agriculture as part of the entrance requirements to college courses. Many students in high schools who look forward to college work have thus been discouraged from taking work in agriculture, and in some cases this negative influence of the higher institutions has resulted in the abandonment of agricultural courses in high schools. It is encouraging to note in this connection, however, that some of the leading institutions in this country now include agriculture among the subjects upon which entrance credits will be allowed.

In Texas not only the public schools, which are required to teach elementary agriculture, but also many of the high schools not included in the legislation of a year ago have taken steps to teach this subject. At Pilot Point, Tex., agriculture is made a part of the regular work of the eleventh grade in the high school. The apparatus of the physical laboratory is utilized, supplemented by fruit jars, bottles, and other inexpensive materials which can be used in laboratory exercises and experiments. The superintendent of the school writes that as a result of the introduction of agriculture the course in botany has taken on a more practical trend, and in fact "agriculture has given unity and purpose to the whole science course." The course in nature study is now being reorganized so that it will articulate with agriculture, and there will be progressive work with nature material all through the grades and in the high school.

The board of education of Pine Bluff, Ark., has introduced a three-year course in agriculture into the schools of that city. Instruction in agriculture was begun at the Missouri Street High School in September.

In Tennessee the Farragut School has been placed under different management with the idea of strengthening the agricultural work. Agriculture is also taught in the Hamilton County High School at Tyner, Tenn.

A new agricultural high school at Crookston, Minn., has an appropriation of $4,000 annually for maintenance. A dormitory and dining hall costing $50,000 and an industrial building costing $15,000 have been erected.

The Illinois College, Jacksonville, Ill., has recently received a bequest from the late Mrs. Phoebe G. Strawn of $20,000 for instruction in agriculture. The college has inaugurated secondary work in agriculture by offering courses in soil fertility and fertilizers, soil physics, agricultural botany, and agricultural zoology. This work is supplemented by occasional lectures by experts in agriculture. Dean Davenport, of the college of agriculture of the University of Illinois, gave the first lecture on "The relation of agriculture to a system of universal education." C. G. Hopkins and F. H. Rankin also represented the college of agriculture in the lecture course, and C. A. Rowe gave a series of lectures on corn culture, breeding, and judging. In this connection it is interesting to note that Illinois college was the first institution to erect a building for higher education in Illinois, and that one of its early professors, Jonathan Baldwin Turner, was a leading spirit in securing legislation giving Government aid to land-grant colleges.

RECENT LEGISLATION.

ALABAMA.

The legislature of Alabama has increased the State appropriation for each of the district agricultural schools from $2,500 to $4,000 annually. Arrangements have been made by this Office to secure a full report upon the organization, resources, and work of these schools, which will be published soon.

MICHIGAN.

The recent act of the Michigan legislature (1907) providing for county agricultural schools places these schools under the direct control of county school boards consisting of five members, including the county commissioner of schools and four members appointed by the board of supervisors. The law also provides that the course of

study shall extend over two years and shall include instruction in the elements of agriculture (the soil, plant life, animal life, and farm accounts), manual training, domestic economy, and other related subjects, and that each school shall have a tract of land suitable for experiment and demonstration of not less than 10 acres. Short winter courses are also to be held. The State superintendent of public instruction, with the advice of the president of the Michigan State Agricultural College, is to have general supervision of all schools established and may prescribe the necessary requirements for the organization and maintenance of them and the qualifications of teachers, except that no person shall be eligible to the position of superintendent of any school who is not a graduate of a State agricultural college.

MISSISSIPPI.

A recent law in Mississippi provides that there may be, upon the initiative of the county, one agricultural high school for each county, and a school tax may be levied not to exceed 2 mills. When the schools are located and the school and dormitory buildings are erected for a capacity of not less than 40 in the high-school department and when 20 acres of land are given, the school is inspected by the State superintendent. Each school approved by the State superintendent is given $1,000. There are 75 counties in the State and several of these have already made plans to establish agricultural high schools. These schools are to teach agriculture and domestic science, in connection with academic work.

NEW YORK.

The New York State legislature has appropriated $80,000 for the establishment and maintenance of an agricultural school in connection with Alfred University, Alfred, N. Y. Of this sum $5,000 is to be used for maintenance the first year, after which the regular maintenance fund will be $10,000. The school has a farm of 200 acres, and will be provided with a new main building costing $30,000, a barn costing $10,000, a dairy and creamery, and a small greenhouse. The dedication of the new school took place June 10, among the speakers being Director Bailey, of Cornell University, who was subsequently given the degree of LL. D.

An appropriation of $20,000 was also granted for the establishment of an agricultural school of secondary grade at Morrisville.

The charter under which the agricultural school at St. Lawrence University was established has been so amended as to restrict the instruction to elementary and practical courses, to be given only at the university.

OKLAHOMA.

The legislature of Oklahoma, in carrying out the provisions of the State constitution requiring the teaching of the "elements of agriculture, horticulture, stock feeding, and domestic science in the common schools," enacted a law approved by the governor of the State May 20, 1908, which provides for an articulated system of instruction in the subjects mentioned, and in forestry, road making, and economics, extending from the agricultural college to the common schools, and makes instruction in these subjects mandatory in all public schools receiving any part of their support from the State.

The institutions provided for include (1) the State Agricultural and Mechanical College, which is made the technical head of this system of education and is required to lend assistance to other institutions in carrying out the aims of the constitution with respect to teaching agricultural and industrial subjects; (2) State normal schools, in each of which a department of agricultural and industrial education, with an appropriation of $2,500 for maintenance, has been established for the purpose of preparing teachers for this work in the public schools of the State; and (3) district agricultural schools of secondary grade in each of the judicial districts of the State, these schools to provide instruction in agriculture, mechanic arts, domestic science, and economics, but not excluding "the common-school branches, languages, manual training, manufactures, the sciences, and other necessary studies, as subjects in the industrial course." The act also provides for the establishment of farmers' short courses in each of these schools. At least two of the schools are to be established in the year beginning July, 1908, and two every two years thereafter until one shall have been provided for in each supreme court judicial district. Each school is to have not less than 80 acres of land, provided for without cost to the State, upon which an experimental farm shall be operated. The appropriation for the first two of these schools is $20,000 each for buildings and $12,000 each for maintenance.

The act also creates a State commission of agricultural and industrial education consisting of the State superintendent of public instruction (chairman), the president of the State board of agriculture, and the president of the agricultural and mechanical college. This commission is subject to the rulings of the State board of education and is required to cooperate with the State normal schools, the agricultural and mechanical colleges and schools, and the State board of agriculture. The commission is required to prepare a detailed course of study in the elements of agriculture and allied subjects, domestic science and economics for the elementary and secondary schools of the State, and to articulate and arrange these courses so

that graduates from the secondary schools may be admitted to the subfreshman or higher years of the agricultural and mechanical college without further examination. The State superintendent of public instruction is also required to send examination questions twice a year to each county superintendent of schools covering all studies required for admission to the agricultural and mechanical college, and the county superintendent is required to conduct examinations for admission to the college in the same manner that the teachers' examinations are conducted.

There is also to be established in the agricultural and mechanical college a chair of agriculture for schools, the occupant of which shall advise with these schools in all matters relating to the teaching of agriculture and allied subjects, visit the schools, teachers' institutes, the summer normal schools and the State normal schools, and advise with the teachers and officers concerning improvement of methods of teaching, appliances, and the use of seeds, plants, and trees. He is required to prepare, print, and distribute leaflets and other literature helpful to teachers and pupils.

VIRGINIA.

The general assembly of 1906 gave $50,000 a year to encourage the establishment of high schools in rural communities. The assembly of 1908, which adjourned in March, doubled the annual appropriation for the extension of high schools in rural communities and in addition gave $15,000 a year to establish, in connection with certain high schools, county training schools for teachers, following the Michigan, Wisconsin, and Nebraska plans. The training school will be a one-year course in normal methods, in school hygiene, English, mathematics, elementary psychology, music, etc. These training schools are to be located by the State board of education under such rules and regulations as it may see fit to make, but not over $1,500 is to be used in any one school. This amount is to be used exclusively for the pay of the teacher or teachers in the training school. No training school will be established except in a four-year high school, where class rooms are adequate, or in any place except where boarding facilities are sufficient. The attendance will be restricted to graduates of at least a three-year high school, and to such teachers as may wish to improve themselves in scholarship and method. The course will be for one year, and practical work will be done in connection with the graded school at hand. It is expected that about fifteen of these training schools will be established.

In addition to this appropriation for training schools, the assembly of 1908 gave $20,000 a year for two years with which to commence in each Congressional district the teaching of agriculture and domestic

science in connection with certain high schools. This gives $2,000 for each of such schools, this amount to be used exclusively for teaching and to be supplemental to what the local communities will add. Already a spirited contest has begun for these schools. Manassas, with an offer of $25,000 and 15 acres of land, was the first to secure this appropriation from the State. Appomattox, a town of 450 people, has raised $5,000 by private subscription, and will erect a $10,000 building and give all the land desired if thereby she may secure the State appropriation. Burkeville, Hampton, and Middletown are also in the contest for a part of the appropriation.

AGRICULTURE IN NORMAL SCHOOLS.

The movement for the introduction of agriculture into State normal schools is growing, and in nearly every case where a new normal school is established provision is made for teaching agriculture.

In accordance with a recent act of the legislature a new normal school was established in Arkansas this year at Conway, and a department of agriculture was organized, with L. A. Niven in charge.

In Virginia the last legislature provided for new normal schools at Fredericksburg and Harrisonburg, and it is understood that agriculture will be taught in both of these institutions.

JOHN SWANEY CONSOLIDATED SCHOOL, McNABB, ILL.

Among the notable developments in rural education in the last two years is the John Swaney Consolidated School, in Magnolia Township, Putnam County, Ill. For the facts concerning this school and for much of the language in the following statements the writer is indebted to O. J. Kern, county superintendent of schools in Winnebago County, Ill., who visited the school and has published the results of his observations in his annual school report and in a report of the committee of the National Education Association on Industrial Education in Schools for Rural Communities. The school is located out in the country, 2 miles from the small village of McNabb, and is housed in a $12,000 brick building, which stands near the north side of the beautiful campus consisting of 24 acres of timber pasture. This campus was donated by Mr. John Swaney, a farmer of moderate circumstances, who believes in better things for country children.

FINANCIAL DATA.

The consolidated school district comprises three ordinary country school districts, which were consolidated by due process under the Illinois school law. It comprises fourteen sections of land, assessed at $179,000, which is supposed to represent one-fifth of the fair cash

value. The selling price of improved farms, which comprise three-fourths of the district, is \$150 an acre, and of the timber land, which comprises the remaining one-fourth, is \$75 an acre. The school levy for the school year of 1907–8 was \$2,900 for the building fund to pay bonds issued for the erection of the new building, and \$3,900 for general educational purposes, securing better teachers, janitor service, etc. Twenty pupils are paying tuition at present, bringing in an annual revenue of \$375. Practically all the money raised for school purposes in Illinois is raised by local taxation.

TRANSPORTATION.

Two teams are employed in bringing in the children from two of the old districts. The wagons cost \$175 each and are owned by the district. The distance, round trip, for one wagon is 9 miles and 9½ miles for the other. Drivers of the wagons are farmer boys living in the community, who are in the high-school room. The horses are put in the school barn, located on the campus. Each team costs \$40 per month for 22 round trips, thus making an outlay of \$1.82 per day for each wagon. As each wagon carries 20 children, the cost per pupil daily is 9 cents, about the price of two street-car fares in a city.

BUILDINGS AND EQUIPMENT.

The main building is a brick structure, two and a half stories high, containing four recitation rooms, two laboratories, a large auditorium, two library and office rooms, a boys' manual training room, a girls' play room, furnace room, and cloakrooms. All are lighted with gasoline gas generated by a plant, the reservoir of which is stored outside of the building. The laboratories are also furnished with gas from this plant. The building is heated with steam and furnished with running water supplied by an air-pressure system. The building and equipment cost \$16,000.

Four or five farmers, at their own expense, fitted up one of the abandoned schoolhouses for a teachers' home, thus solving the problem of a boarding place for the teachers. The cost to the farmers was \$500. The teachers pay \$9 a month rent and hire an elderly woman for housekeeper. The teachers club together for the living expenses of the home.

An old tenant building located on the school grounds was fitted up for a janitor's home. The janitor has charge of the grounds, school building, and stables. He receives a salary of \$30 per month and pays \$5 per month rent for his home.

As noted above, there is a beautiful campus of 24 acres of pasture land, dotted with groups of native forest trees. It is the purpose of the district to beautify the grounds still further, according to the

plans of the horticultural department of the Illinois College of Agriculture. In addition to this donation, the school received from the county superintendent a set of manual training tools, and from other contributors various sums of money. In all, about $2,000, besides grounds, were donated to the school.

COURSE OF STUDY.

In the first eight grades the work of the school follows closely the outline in the State course of study. The industrial features of this course include construction work for the first and second grades, bench work for the eighth grade, household arts in connection with physiology for the seventh and eighth grades, and elementary agriculture in the seventh and eighth grades. Three twenty-minute periods a week are given to elementary agriculture.

In the high school agriculture, manual training, and domestic arts occupy a prominent place, but the cultural studies of the students are not neglected. An outline of the entire course is given below:

Four-Year High School Course.

FIRST YEAR.

First semester:	Second semester:
English I.	English I.
Algebra.	Algebra.
Physiology.	Physical geography.
Agronomy I or Latin.	Horticulture or Latin.
Household science or manual training.	Household science or manual training.

SECOND YEAR.

First semester:	Second semester:
English II.	English II.
Algebra, 10 weeks.	Geometry.
Geometry, 10 weeks.	Botany.
Zoology.	Ancient history, 10 weeks.
Ancient history.	Animal husbandry or household science, 10 weeks.
Drawing.	Music.

THIRD YEAR.

First semester:	Second semester:
English III.	English III.
Chemistry.	Chemistry.
Agronomy II or Latin or household science.	Animal husbandry or Latin or household science.
English history.	English history.

FOURTH YEAR.

First semester:	Second semetser:
English IV.	English IV.
Physics.	Physics.
Household science or Agronomy III.	Bookkeeping, 10 weeks.
American History.	Arithmetic, 10 weeks.
	Civics.

A brief outline of the work in manual training, household science, and agriculture is here given.

Household Science.

Two and one-half years' work is offered in household science. The course runs parallel with that of the manual training and a part of the agriculture, and is elective. It includes an elementary study of:

(1) The composition and nutritive value of our common foods.

(2) Their relation to the needs of the body.

(3) The principles of cooking of different foods.

Besides this some work will be done in sewing and raffia weaving.

The first year only two hours a week are devoted to the work.

Manual Training.

Two hours a week during both semesters of the first year will be devoted to manual training. The course will be made up of a study of the construction of our common tools and of the structure of different kinds of woods. Benchwork will be done; this work will occupy most of the time.

Agriculture—Agronomy I.

This course consists of a study of the seeds of our common grasses, grains, and garden vegetables. Some of the subjects noted are: The separation, identification, germination, and vitality of these seeds. The corn score card is also studied, and practical work in scoring is done. Along with this is a study of our most harmful weeds and modes of eradicating them. Shaw's Weeds and How to Eradicate Them is used as a text. Bulletins from experiment stations are made use of.

Agronomy II—Soil Physics.

In this course a study is made of the physical features of the soil. The origin of soils; different types of soils and their characteristics; the composition of these soils and their behavior under different treatments, are some of the subjects which will be considered. The work from the text will be supplemented by laboratory exercises, which will occupy half the time given to the course. Laboratory work will be recorded in notebooks.

Agronomy III—Soil Fertility.

In this course the chemical constituents of the soil will be considered. The effects of the rotation of crops and the different systems of farming will be noted. Laboratory work will accompany the recitation work. Bulletins from the experiment stations will be made use of. Notebooks will be kept.

Animal Husbandry I.

This course occupies the second half of the semester and takes up the study of swine; market classes and their grades, the breeding and care of swine, and judging will be studied.

Animal Husbandry II.

This includes a semester's work, the first half of which will include a study of the principles of feeding. The second half will be given to the judging of horses and cattle.

Horticulture.

This course takes up the principles of fruit growing. The following subjects respecting fruit lands are considered: Location and climate, tillage, fertilizing, planting, and incidental care. Diseases of fruits, insects which injure fruits, and spraying are also studied. Pruning receives much attention. Field trips and laboratory work supplement the texts, which are The Principles of Fruit Growing and The Pruning Book, both by L. H. Bailey.

Experiment Station.

In order that the State may learn the needs and methods of improvement of the different large soil areas, experiment stations are established in these areas; in all there are now 23. One of these stations is now being installed adjoining the campus on the east. This station contains a plat of ground consisting of 6 acres, and is divided into four series, with five breeding plats in each series. This is to be conducted by the State, but the school will have the privilege of observing the work of the station and will have access to the records of results.

WORK OF THE HIGH SCHOOL.

In his report to the National Education Association, Mr. Kern speaks of the work in agriculture and other sciences as follows:

This room was visited in the afternoon and a recitation in agronomy was the first exercise. The first and second year classes were combined for this particular recitation. Corn was the subject of study, with Reid Yellow Dent as the particular variety. Each pupil had brought corn from home, and they were studying samples according to the score card adopted by the Illinois Corn Growers' Association. The principal of the school called on each member of the class to state which ear of the number he had brought had the best tips, the best butts, and the various items as given on the score card. The pupils were required to give a reason for their answers. The answers revealed that some observation and thinking had been done. Shapes of ears, kernel shape, yields or variety, etc., were discussed. While this was going on, two boys in the soil-study class were testing soils for loss of organic matter. Types of both the cropped and uncropped soils were being used for this test. The gasoline plant in connection with the building furnished the heat for the experimental work as well as the domestic science work. The air-pressure water tank in the basement furnished water necessary for laboratory purposes.

In the regular science work an earnest effort was being made, with success, to correlate with the environment of the pupil. Thus the zoology correlated with fall agriculture. Emphasis was being placed on the life history of insects as related to the farm, their economic value, etc. The principal took the

pupils to the fields and made an examination of corn roots to find the insects injurious to corn. A new insect was discovered and sent to the college of agriculture at the University of Illinois for identification. In addition to the regular text on zoology, use was made of the United States entomological bulletins and the very valuable reports of Professor Forbes, who, under special appropriation of the Illinois legislature, is making most important investigations with reference to insects injurious to the Illinois farmer. No more valuable bulletin in that particular subject has been printed than the one by Professor Forbes on Insects Injurious to Indian Corn. The future farmers in this school were having this information brought in as a part of their science work, in economic zoology. This could be done in this country school, with a high-school course flavored with country life and its interests, for two reasons, mainly: First, the school was so organized and equipped that it was possible to relate the laboratory and class room with the immediate environment of the pupils; second, there was a trained teacher with a sympathetic insight into the conditions of country life and a realization of the importance of vitalizing these conditions in the training of country children; a teacher who vitalized his science work with a study of environment; a country high-school science teacher who did not put the emphasis on the oyster or the lower forms of marine life.

Likewise with botany: The pupils did have notebooks in their science work; they did make drawings of flowers, plants, and insects; they did mount specimens, etc. But they went further. They planted seeds at school and home and made a study in an experimental way to discover the relations of plants to soil, water, climate, etc.

In the soil work the instruction was practical and scientific. In this subject, especially, one could note how this high school was putting these farmer boys in touch with the great soil work carried on by the Illinois College of Agriculture under the direction of Dr. C. G. Hopkins. In class room and laboratory, use was being made of King's The Soil, Mosier's Soil Physics (this a laboratory manual), and bulletins from the Illinois Experiment Station. Last, but not least, the school had access to the experimental plat of 6 acres adjoining the school campus. The Illinois College of Agriculture has a ninety-nine year lease on this small field, and under the direction of the faculty of this college some valuable experimental work is being carried on, not only in soil improvement, but in crop rotation, farm practices, etc. This being close to the school, as was stated, it becomes a valuable out-door laboratory for both the school and the farmer of the consolidated district. The three and one-half years' work in agriculture are made just as scientific as the physics or chemistry work. The horticulture work is made as scientific as the botany work in the ordinary high school. Thus in economic entomology, "worms" working on vegetation were brought to the schoolroom and placed in jars. Cages were shown that had been made by the pupils for the larva, and as soon as the larva had passed into the pupa state, this pupa was put away in a safe place for spring study. Some specimens were being preserved in formaldehyde. In the agronomy work a collection was made of the worst weeds on the farm to be studied in connection with the text. There were small bottles of seeds. A collection especially noted, collected by a boy, contained the following injurious weed seeds: Spanish needles, pepper grass, mustard, plantain, tickle grass, giant ragweed, foxtail, ragweed, wild parsnip, lamb's-quarter, wild sunflower, horse mint, sand bur, cocklebur.

The building was well equipped with the necessary laboratories. One member of the school board is a graduate of the University of Illinois and a farmer. A second is a graduate of the Central Illinois State Normal School and also a

farmer. The third member of the board is an intelligent farmer, and their wisdom is strikingly shown in the way they have equipped the school building for doing good work. This is possible in a consolidated school that fits local conditions; and, lastly, a consolidated school with a board and community actuated by liberal ideas and right ideals in the equipment of a building and the employment of trained teachers to manage the educational plant for training boys and girls in the life they now live.

Shopwork in manual training was not in progress at the time this visit was made, but the visitor did see the domestic science work in the chemistry laboratory. All years of the high school were represented. Cream of wheat was the especial subject of study for the day. The girls were getting a training in food values, chemistry of foods, preparation of food for the table, etc. The teacher had training for this special work, and in addition taught Latin and English as a part of her regular high-school work. The principal taught agriculture, manual training, science, and some mathematics. The literature, language, and some history were taught by the domestic-science teacher. These country girls were having their school work related to the home life in a most helpful manner.

Some of this may be done in the one-room school as now organized, provided the proper equipment and a properly prepared teacher are furnished, but it will then be a very expensive school, based on the day's average attendance. Even thus vitalized it will still lack the social enrichment possible in the larger unit. And it is the larger social participation that must enrich the life of country people. This social efficiency must come through education. The ideal conditions seems to obtain at the John Swaney Consolidated School. The unit is not so large as to take away the local character of the school. It is still a country school beside a country road. And the work of the schoolroom is not entirely industrial. It seems that a right balance of educational values is being maintained.

A few schools like this one are needed, scattered over the country, to show what is really possible for thousands of farming communities. With that there must be some medium to let those communities know what is going on out on the front line of country-school improvement. That medium, whatever it is, must be a medium thoroughly in sympathy with country life and its interests and occupations.

CANBY PUBLIC SCHOOL, CANBY, MINN.

Canby is a village of about 1,700 inhabitants. Its public schools include the usual elementary and grammar grades, extending over eight years and a four-year high-school course. The faculty of the high school consists of the superintendent, principal, teacher of languages, a teacher of science, a teacher of girls' industrial subjects, and a teacher of agriculture and woodwork. The last is employed by the year, so that he may have charge of the field work in agriculture and school gardening during the summer months. The high-school building is a fine brick structure, having two stories above a high basement (Pl. XI, fig. 1). The school has 9 acres of land available for school gardens and other agricultural work (Pl. XI, fig. 2).

During 1908 an elective course in agriculture was offered in the eighth grade, two hours a week, with Goff and Mayne's First Princi-

ples of Agriculture as the basis for the work. About thirty-five pupils carried the agricultural work throughout the year.

There were also school gardens for all grade pupils who chose to engage in such work, and about one hundred pupils availed themselves of the opportunity. The following financial statement concerning the school gardens and other agricultural field work has been furnished by the superintendent of the school:

EXPENDITURES.

Team work	$78.50
Man work	16.92
Instructor	210.00
Lumber	1.94
Rake, hoe, spade, sprinkler	2.55
Wheelbarrow	1.85
Baskets, sacks	2.00
Cultivator	2.75
Formaldehyde, fruit jars	1.25
Land rental	41.66
Seeds	22.68
Total	382.10

RECEIPTS.

Cabbages, etc	3.40
Potatoes	30.37
Wheat	4.10
Small corn	25.25
Celery on hand	4.15
100 bushels selected seed corn on hand	300.00
Balance	14.83
Total	382.10

The only item in the above statement concerning which there is any question is that of $300 for 100 bushels of seed corn, but the superintendent states that there is sufficient demand for carefully selected seed corn to warrant his estimating it at $3 a bushel. The garden was nearly self-supporting. There is an apparent excess of expenditures over receipts amounting to $14.83, but it will be noticed that there are items in the expense account for equipment amounting to over $11 which should not be charged entirely to the expenses of this first year.

The field work in agriculture included not only school gardens but considerable work with farm crops. One acre was devoted to farm rotations, ½ acre to alfalfa, ½ acre to alsike clover, 1 acre to potatoes, 1 acre to school gardens, and 5 acres to pure-bred Minnesota No. 13 corn. The school garden plats were each 25 by 10 feet and included common garden vegetables and flowers.

During the year 1909 the Canby schools will offer one hour a week of sewing or woodwork for pupils in grades five to eight, inclusive,

FIG. 1.—HIGH-SCHOOL BUILDING, CANBY, MINN.

FIG. 2.—SCHOOL GARDENS AT CANBY, MINN.

and five hours a week in the first year of the high-school course in sewing and cooking for girls, and agriculture and carpentry for boys.

There has also been announced a short course for boys opening November 16 and continuing three and a half months. The classes will meet Mondays, Wednesdays, and Fridays, from 10 a. m. to 2 p. m., and will be open to boys who have completed the work in rural schools. The work offered in the short course includes six weeks of general agriculture, three weeks of horticulture, five weeks of animal husbandry, and courses in carpentry, English, and arithmetic extending over three and a half months.

LOGAN COUNTY HIGH SCHOOL, GUTHRIE, OKLA.

The Logan County High School offers five courses of instruction, classical, normal, business, agricultural, and preparatory, each extending over four years. Below is given an outline of the agricultural course.

FIRST YEAR.

First semester:	Second semester:
English.	English.
Algebra.	Algebra.
Physiography.	Physiography.
Elementary agriculture.	Breeds of live stock.
	Stock judging.

SECOND YEAR.

First semester:	Second semester:
English.	English.
Algebra.	Geometry.
Bookkeeping.	Shorthand (elective).
Economic botany.	Economic zoology.

THIRD YEAR.

First semester:	Second semester:
English.	English.
Geometry.	Geometry.
Physics.	Physics.
Soils and soil physics practice.	Nursery principles.
German.	Spraying of plants.
	German.

FOURTH YEAR.

First semester:	Second semester:
Psychology.	English.
German.	German.
Chemistry.	Chemistry.
English or American history.	English or American history.
Principles of fruit culture.	Farm crops.
Judging farm crops.	Rural engineering.
	Farm machinery.

UNIVERSITY PREPARATORY SCHOOL, TONKAWA, OKLA.

Agriculture was introduced into this school last year for the first time and is included among the electives, along with manual training, domestic science, bookkeeping, stenography, typewriting, etc.

The school also announces a regular agricultural course, an outline of which is given below. The figures indicate the number of weekly recitations of the respective studies.

Agricultural Course.

FIRST YEAR.

First semester:		Second semester:	
English	5	Manual training	6
Arithmetic	5	Mechanical drawing	4
History	3	Physical training	3
Agriculture	5		

SECOND YEAR.

First semester:		Second semester:	
Algebra—Geometry	5	Commercial law (half year)	5
Chemistry	7	Bookkeeping	10
Stock judging, Zoology	7	Public speaking	3

THIRD YEAR.

First semester:		Second semester:	
English	5	History	3
Algebra	5	Manual training	6
Botany, Grain judging, Horticulture	7	Mechanical drawing	4
		Physical training	3

FOURTH YEAR.

First semester:		Second semester:	
Physics	7	Advanced agriculture	7
Geometry	5	Political economy	5
History, Civics	5		

The text-books used include Soils by Fletcher, Cereal Crops in America by Hunt, Forage Crops by Shaw, Types and Breeds of Farm Animals by Plumb, Farm Management by Card.

Laboratory and fieldwork is carried on in connection with the text-book work and includes experiments to illustrate the physical properties of soils, exercises in pruning, propagating and garden-making, seed testing, grain judging, field trips to study farm crops, and stock judging.

The work of the fourth year, "advanced agriculture," is a study of farm management in which the text-book work is supplemented by the drawing of plans for different farms, and planning systems of farming for the farms upon which the students live.

THE ELEMENTARY SCHOOLS.

Oklahoma and West Virginia have been added to the list of States requiring the teaching of agriculture in all rural schools. As noted earlier in this review, much more attention than formerly is now being given to summer schools and other means of affording instruction and training for teachers who expect to take up the teaching of agriculture.

School gardens have not been generally successful in connection with rural schools, except where combined with home gardens or with boys' agricultural clubs or girls' home culture clubs or other like enterprises designed to connect the school work with that of the home. The club movement apparently embodies just enough of the real business of farming and home making and of the elements of competition to make it appeal to the boys and girls and to sustain their interest throughout the season.

At the request of Congressman J. C. McLaughlin, of Michigan, this Office cooperated with the Michigan Agricultural College in organizing boys' corn-growing contests in Muskegon and Mason counties, in Michigan, with an initial membership of nearly 600.

In Nebraska, Kansas, Indiana, and Missouri the boys' and girls' club movement has made rapid strides during the year, and it is the plan to have a big meeting of these contestants and exhibits of their products at the National Corn Exposition in Omaha. There have also been notable developments in the club movement in Georgia, Louisiana, and other Southern States.

In the cities there have been several notable successes in conducting children's gardens, and the gardens conducted in connection with the city schools have been rather more successful than similar work in the country. The garden movement in the city of Washington has made considerable progress during the year, and similar enterprises in New York, Philadelphia, Yonkers, and other cities mentioned in previous reviews have been continued. School gardens have been a feature of the work of the schools of San Antonio, Tex., for two years and have been very successfully conducted under a supervisor of gardening. Recently a citizen of San Antonio donated the use of an acre of ground for permanent garden work and on this site a garden laboratory was erected.

In Cleveland the garden work was started by the Home Gardening Association, but of late it has been developed considerably in

connection with the public schools. The school gardens as now organized include: (1) Gardens for normal children, as at the Warren, Doan, and Rosedale schools; (2) gardens for defective or backward children, as at the Outhwait, Fowler, Oakland, and Orchard schools; (3) a garden for delinquents; and (4) a kitchen garden in connection with the cooking school for the elementary grade conducted at the Oakland school. While this work is carried on in connection with the schools and is supported by the school fund, it is not yet a part of the school curriculum, being entirely voluntary on the part of the children and done outside of school hours. All of the garden work in connection with the schools is under the immediate direction of the superintendent of gardens, who in turn is responsible to the curator of school gardens and school grounds.

The Home Gardening Association continues to lay emphasis upon the encouragement of gardening at home among the poor classes and the improvement of home grounds, but for two years it has also conducted what is known as the training garden (Pl. XII, fig. 1), where some of the larger boys and girls who have gained some experience in gardening in connection with school gardens or isolated home gardens, and who show an aptitude and a desire for this kind of work are given an opportunity to cultivate larger gardens and to learn the use of the wheel-hoe, drill, and other tools used in commercial gardening (Pl. XII, fig. 2).

The training garden includes an area of about 3½ acres, which is divided into narrow plats extending the length of the field, and thus gives excellent opportunity for cultivating vegetables in long rows according to improved modern methods. One feature of the training garden is a model garden, 60 by 100 feet, planted entirely to the 24 kinds of seeds which the Home Gardening Association puts up in penny packets to sell to children. This garden is thus a demonstration of what can be done with 24 cents' worth of seeds.

FIG. 1.—CLEVELAND HOME GARDENING ASSOCIATION TRAINING GARDEN.

FIG. 2.—CLEVELAND HOME GARDENING ASSOCIATION TRAINING GARDEN BOYS, AND THE TOOLS THEY LEARN TO USE.

THE FARMERS' INSTITUTES IN THE UNITED STATES, 1908.

By John Hamilton,

Farmers' Institute Specialist, Office of Experiment Stations.

Farmers' institutes have been held during the past year in all of the States excepting Louisiana and Nevada, and in all the Territories excepting Alaska and Porto Rico. Although an appropriation of $2,000 was made for farmers' institutes in the State of Louisiana none was held, owing to the fact that the commissioner of agriculture, who is in charge of this work, was unable, because of the pressure of other duties, to undertake it.

In both Alaska and Porto Rico the institutes can not be said to have been undertaken in the form in which this work is conducted in the States. However, the directors of the experiment stations in these Territories have performed practical institute service by visiting the farmers and giving them instruction at their homes.

INSTITUTES HELD.

Reports have been received from 49 States and Territories, and in 46 of these institutes were held. The reports show marked progress in institute activity in all directions, in increased attendance, in the number of institutes and sessions of institutes held, and in the amount of money appropriated for institute work. In 45 States and Territories the number of institutes held is given at 4,643. Forty-two of these States and Territories held, in 1908, 4,542 institutes. The same 42 States and Territories, in 1907, held 3,870 institutes, an increase in 1908 of 672 institutes.

A comparison of the number of one-day, two-day, and three-day institutes held in 1908 with those of similar duration held in 1907 shows a general tendency toward increasing the number of one-day meetings. The 45 States reporting held, in 1908, 2,737 one-day institutes, 1,808 two-day institutes, and 98 three-day institutes. This represents an increase over 1907 of 674 one-day institutes, 24 two-day institutes, and 18 three-day institutes. Forty-five States report for 1908 the total number of days of institutes held at 6,528, an increase over 1907 of 670 days.

SESSIONS.

Forty-four States held 14,934 sessions of institutes in 1908. Comparing the number of sessions held in 42 of these States with the number held by them in 1907, an increase is shown for 1908 of 3,173 sessions, or 27.8 per cent. Inasmuch as the institute session is the proper unit for estimating institute progress, the large number held during the past year above the previous year is convincing proof of increasing interest and of rapid extension in this work.

ATTENDANCE.

The total attendance reported by 44 States for 1908 amounted to 2,098,268. Forty-two of these States, in 1907, reported an attendance of 1,589,852. The same 42 States, in 1908, report an attendance of 2,059,342, an increase in 1908 of 469,490.

Forty-four States report for 1908 an average attendance per session of 140. The attendance in 42 of these States in 1908 averaged 141, and the same 42 States in 1907 averaged 139.

APPROPRIATIONS FOR INSTITUTES.

The total appropriations for the year from all sources is given by 47 States and Territories at $325,569.54, an increase of $41,118.87 over 1907.

THE COST OF THE INSTITUTES.

Forty-six States in 1908 report the total cost of their institutes at $297,356.89, an increase of $35,507.21. The larger number of sessions held in 1908, however, reduces the cost per session from $27.93 in 1907 to $19.91 in 1908.

COLLEGE AND EXPERIMENT STATION AID.

There has been an increase during the year in the number of college and experiment station lecturers engaged in institute work. Forty-one States report the number of college and station lecturers at 426, an increase over 1907 of 40. The total number of days contributed by the colleges and stations in 1908 was 3,851, an increase of 295 over 1907.

SPECIAL INSTITUTES.

Sixteen States are reported as having held independent institutes. The total number of sessions is given at 142 and the attendance at 81,845. Eleven States report round-up institutes consisting of 99 sessions with an attendance of 28,910. Eight States conducted railroad specials. The attendance at 7 of these was 218,710. Ten States

held movable schools of agriculture, with an attendance of 6,849; and two States held field meetings continuing through nine days, attended by 4,100 persons, making the total attendance upon these five forms of activity 340,414, which, added to 2,098,268, the attendance at the regular institutes, will make a total of 2,438,682. In addition to this number there was the attendance upon the following forms of institutes, for which no record of attendance is given: Women's institutes in 15 States, 732 meetings; boys' institutes in 5 States, 174 meetings; normal institutes in 5 States; street fairs in 1 State; and a large number of farmers' picnics, addressed by farmers' institute lecturers.

IMPROVED METHODS.

In a number of States the institute authorities have departed from the beaten track which the institutes have been pursuing during their past history and have undertaken to supplement the work by giving more specific and extended instruction than was possible under the form of institute that was formerly in use.

In Arizona the director of institutes conducted meetings during eight weeks, holding the sessions at night and mingling with the farmers in demonstration and advisory work during the day. At one point during the term of the institutes he taught three classes in agriculture in the local academy during the day and held institute meetings at night. During the institute season the lecture force returned to each locality every two weeks for institute meetings, and there were also organized in each of these localities permanent institute societies.

In Mississippi, the farmers' institute, by action of the board of trustees of the agricultural college, has been made a department of the college, and additional force has been secured to assist in carrying on the work.

In Maryland, the institute department, which is under the control of the Maryland Agricultural College, purchased a private car with Pullman equipment, which was used for short-course work in institute schools. Students in various localities throughout the State were registered in advance and formed into classes, agreeing to attend all of the sessions of the course to be held in their several localities. The course consisted of six lectures upon leading agricultural subjects. During the intervals between lectures, farms, orchards, stables, and poultry yards were visited and inspected and expert advice given respecting their treatment. Visitors to the car were also met and the practical character of the exhibits explained. The schools were continued for one month on the line of the Maryland and Pennsylvania Railroad, having a total registered attendance of 1,714.

In the State of Washington 3 traveling dairy schools were equipped and sent out, each remaining in a locality five days; and

8 street fairs were held at various points, to which farmers brought stock, grain, and various other kinds of produce for sale.

In Colorado, 12 farmers' short courses and 3 domestic-science short courses were held in as many different sections of the State. From 9 to 14 lecturers were sent to each farmers' short course and 4 lecturers to each domestic-science short course. To secure a farmers' short course 100 farmers were required to agree to attend and each pay a tuition fee of $2. For a domestic-science course 50 women had to agree to attend at a tuition fee of $1. The total enrollment in the farmers' short courses was 1,101, and in the domestic-science short courses 1,034. The success of the movement is so pronounced that the director is planning to extend the work and hold during the coming season 24 farmers' short courses and 10 short courses in domestic science.

COLLEGE-EXTENSION WORK.

A most encouraging fact connected with the dissemination of agricultural information among rural people is the interest that is taken in this movement by the agricultural colleges and experiment stations. New York, Maine, Pennsylvania, Ohio, Indiana, West Virginia, Colorado, California, Illinois, Nebraska, Iowa, Kansas, Rhode Island, Utah, and Wisconsin have all organized for extension work.

Perhaps the best-equipped effort in the direction of carrying agricultural information to farmers by the agricultural colleges has been in operation in the State of Iowa. A corps of 10 expert lecturers, organized and sent out by the State Agricultural College, has been engaged in giving instruction to classes of farmers, remaining a week in a locality. Those who attend the meetings are divided into sections or groups corresponding with the main features of the agriculture of the community. A distinct course of instruction is provided for each group—one upon corn judging, another upon stock rearing and judging, another on domestic science, etc. The attendance upon these courses and the interest in the instruction given have been very satisfactory—so much so that the college feels justified not only in continuing the work, but it expects to greatly enlarge it during the coming year. With this in view, schemes of instruction have been prepared outlining and systematizing the courses, rendering them more practical and complete.

THE AMERICAN ASSOCIATION OF FARMERS' INSTITUTE WORKERS.

The annual convention of the American Association of Farmers' Institute Workers in Washington, D. C., November 16–17, 1908, was the best attended of any previously held. Two hundred and fifty-seven persons registered, representing 42 States, 1 Territory, and

3 provinces of Canada, besides one visitor each from New Zealand and the Transvaal.

The subjects for discussion in the general programme were mainly directed toward defining the status of the farmers' institute in its relation to other forms of agricultural education. The points brought out were that the farmers' institute occupies the position of field agent for agricultural education; that it provides a most efficient channel for carrying agricultural information directly to the farmer who is unable to leave his occupation to go to school; and that it should broaden its work until it embraces other more advanced forms of educational work and extend its efforts until all rural people have full opportunity to enjoy its benefits.

The reports from the Canadian provinces of Alberta, Quebec, Saskatchewan, and Ontario showed that they had held 7,266 half-day sessions of institutes, with an attendance of 321,963. A remarkable development of institutes for women in Canada was shown by the report from the Province of Ontario, where 3,978 sessions for women were held, with an attendance of 93,951.

WORK OF THE OFFICE.

During the year the Farmers' Institute Specialist visited and delivered lectures in institute conventions in 8 States—Indiana, Kentucky, Maine, Michigan, New York, Pennsylvania, South Carolina, and Virginia. He also visited MacDonald College, in the Province of Quebec, Canada, and the Scranton Correspondence School, in Pennsylvania, for the study of their methods in agricultural education extension work.

In addition to conducting the correspondence of the Office, there were prepared for the printer Bulletin 199, Report of the Proceedings of the Twelfth Annual Meeting of the American Association of Farmers' Institute Workers, the Annual Report of the Farmers' Institute Specialist for 1907, and a revised list of the State Directors of Farmers' Institutes and Farmers' Institute Lecturers of the United States. He assisted in editing a Syllabus of an Illustrated Lecture upon Tobacco Growing; also Bulletin No. 200, Course in Cereal Foods and Their Preparation for Movable Schools of Agriculture.

A syllabus of a lecture upon Selecting Beef Cattle was prepared for the Office during the year by Prof. Frederick B. Mumford, of the University of Missouri. The syllabus is accompanied by 15 charts, from which two sets of bromide enlargements have been made for use by farmers' institute lecturers. There has also been prepared a Syllabus of an Illustrated Lecture upon Poultry Rearing by Prof. James W. Dryden, of the Oregon State Agricultural College. Three courses of study for use by movable schools of agriculture are in preparation, as well as several illustrated lectures.

INSTITUTE DEVELOPMENT.

When the institutes began twenty-five years ago the agricultural colleges in this country were new, and their purpose was little understood. They had almost no alumni to represent them, and the few that had been sent out were too fresh from school to advertise agricultural education effectively or to exemplify the value of the colleges as aids in agricultural development. The great body of farming people at that time were either total disbelievers in the practical value of "book learning" for a farmer, or were prejudiced against the new education by the older institutions against whose standards the new colleges were a protest, and whose time-honored maxim, "culture for culture's sake," was in danger of being revised by the land-grant colleges to read, "education for service."

At this point the farmers' institute appeared and began its work as the advocate of the use of better methods in the practical operations of the farm. It became, at the same time, an agency through which the agricultural colleges and the experiment station workers were able to meet farming people face to face, and were thus afforded opportunity to explain the aims of these institutions and show some of the practical results of their work. Since that time the experiment stations have become most important instrumentalities for the advancement of agriculture, and the land-grant colleges have developed into great institutions that have revolutionized the whole system of education in this country, giving instruction along industrial lines to thousands of young men and women each year.

During this period the farmers' institute also grew in public appreciation and importance until now institutes are organized in all of the States, and through them there were reached last year over 2,000,000 people. The force of teachers in the employ of the State directors now numbers over 1,100, and the amount of money annually expended in carrying on the work approximates $300,000.

Notwithstanding the great work that the institutes have accomplished, and their wide popularity, it has been evident for some time that as at present conducted the institute does not and can not supply information sufficient to equip farmers for the successful pursuit of their profession. A forty or sixty minute talk on dairying once or twice a year—which is about as much as the ordinary institute provides—while valuable as far as it goes, will not fit a farmer for the practice of the best methods in conducting a dairy farm. About all that such a lecture can accomplish is to excite interest in the subject. The work of giving instruction sufficient to equip for efficiency in conducting the operations of agriculture is a much more extended matter.

THE UNGRADED COURSE.

The method of giving instruction in common use in the farmers' institutes by lecturing to promiscuous audiences into which are admitted persons of every age, from the most youthful to those of forty or fifty years, and those of most elementary acquirements to others of high-school, normal-school and even college grade, is no longer adapted to the changes that have taken place in rural communities since the institutes began.

During the early stages of the work, when the main purpose was to advertise and exploit agricultural education, the disregarding of age and intellectual qualifications in the hearers was not a serious matter and, indeed, the advertising was probably as effective under this single class organization as any that could have been devised. But now that the work of educational exploitation has in most of the States been accomplished, the time seems to have come when the different degrees of intellectual advancement and practical skill of country people should be recognized, and provision be made for adapting the teaching to the various ages, experience, and degrees of attainment of those whom the institute is undertaking to instruct. In other words, the institute should now become what is in effect a graded school of agriculture, having a primary or elementary section for boys and girls, another section for scholars somewhat more advanced, and another for those of mature years who have had experience in agriculture and considerable intellectual training in the schools. If some such arrangement is not made, scholars of the higher grades can justly complain that the institutes have stopped short of meeting their needs; that they are continuing to devote their main efforts to advertising and exploiting an education whose main characteristics and usefulness are now well known, and are neglecting to provide the amount of technical instruction in agriculture that their scholars need and are prepared to receive. The question now to be decided is, Shall the institute continue to confine itself to teaching the one-class promiscuous school, and turn over the instruction of those who are no longer interested to some other institution or organization that will recognize their more advanced and special needs and will undertake to supply them? There are now in every community persons engaged in agriculture who would be glad to receive instruction of advanced grade, and although these more advanced students are at present in the minority, yet if classes were organized and instruction provided adapted to their needs, their number would undoubtedly rapidly increase and they and the communities in which they reside would be benefited far beyond what will be possible under the system now in use. These persons are already convinced of the

value of agricultural science, and now wish to take up the more advanced study of this science or the various sciences which compose it, and learn how to apply them in their practice. In short, so far as these persons are concerned, the preliminary and preparatory work of the institute has been accomplished. They now need extended, exact, and advanced teaching in order to make them more efficient as farmers and to provide for their future needs. They have graduated from the old form of institute instruction and are ready for the more advanced grades.

This raises several important questions. Among them are: What is there in the extension field of agriculture that might be undertaken by the institute with advantage to such people? What form of organization shall the institute take in order to supply this new demand, and what shall be the method and extent of the teaching? These questions should have immediate attention if the institute is to properly fulfill its mission as a teacher, adviser, and demonstrator of agricultural truth to the masses.

THE MOVABLE SCHOOL.

It is altogether probable that no single instrumentality or organization can be devised that will in all respects meet the need of agricultural people in an educational way. Several agencies no doubt will have to cooperate in bringing about the complete system of agricultural instruction that is to fully meet the needs of farming people.

Among these agencies, and probably the one next in order in the line of agricultural education extension in this country, is the movable school of agriculture. This is the logical outgrowth of the farmers' institute—a development of the institute idea. It is itinerant in character and deals with people who are so situated as to be unable to go from home to school. While it is true that this new feature in education is founded on the institute idea, it is not in consequence of that an "institute." On the contrary, it is a "school," in that it adopts the "school method" in giving instruction. The school method consists: (1) in organized classes; (2) systematic courses of instruction; (3) individual study; (4) skilled instructors; and, (5) stated examinations. It is this systematized method of work applied to agricultural instruction and carried out into the country to classes of farmers organized for study that is meant by the movable school.

The school is unique also in that instruction is given in but a single subject, and its scholars are limited to adults who have had at least common school training and at least a year's experience in the line of farming which the school represents. The length of school term may vary from one week to two or three months, according to the nature of the subject taught. The equipment consists of apparatus sufficient

to furnish each pupil with a complete set for laboratory use; a library with duplicate copies of books for reading and reference; and also a collection of illustrative material for demonstration and practice work. The teaching is by lectures, and the number is limited to one lecture each day. A syllabus of the lecture containing references to authorities on the different points presented is furnished to each student at its close. The lecture is then followed by the looking up of references noted in the syllabus, and later by practice work in the laboratory, in the stable, garden, or field.

The classes are composed of registered students who have agreed to take the entire course and are limited in number of pupils to not less than eight nor more than fifteen in any one class. A small fee is charged to each student, and the locality is expected to provide a room equipped with desks, chairs, heat, light, and water, in which to hold the school, also janitor service, and material for laboratory use, free of expense to those sending out the school. The purpose is to reach and develop the talent of a few selected people in each community by teaching them with considerable degree of thoroughness how to improve their own practice and thereby also become a help to others.

THE COUNTY SECRETARY.

Before the movable school can be operated most effectively there must be some form of local organization to select the students, organize the classes, and assume general oversight of the work.

A competent superintendent or secretary of agriculture in each county whose duty shall be to give his entire attention to the interests of the farmers of that county is most important, and is becoming more so each year as work in agricultural education develops. The value of an expert on the ground who is familiar with the conditions that exist in the county can hardly be overestimated. The old form of voluntary and uncompensated service is no longer adequate for meeting the more extended and specific duties that advanced agriculture requires. A paid expert capable of advising farmers with regard to the improvement of their methods is now a necessity in many counties, and soon will be in all. If the expert is discreet and capable, the farmers will soon come to recognize the fact and be ready to consult him freely, accept his suggestions, and as rapidly as possible incorporate them into their practice.

In some countries this kind of service is so highly regarded that as many as six expert agriculturists are employed in a single county, who give their entire time to lecturing and advising farmers, and to conducting demonstration fields illustrating the value of the methods that they recommend. Under this system there is no time when the local interests of the agriculturists of the county are not being studied by a competent expert or set of experts; and orchardists,

market gardeners, dairymen, cattle feeders and breeders, special and general farmers, have at hand at all times, free of cost, a corps of competent advisers whom they may consult as occasion requires.

THE WINTER AGRICULTURAL HIGH SCHOOL.

If agricultural education in the United States is to be thoroughly organized so as to provide instruction for all of the people, the time must come when agriculture in some form must be taught in the rural public schools. But when that time does come it will not supply the kind of expert assistance that the adult farmer specially needs. The work will of necessity be quite elementary and must ever remain comparatively simple and very general in its application.

There will, therefore, always be the need for schools of advanced grade for teaching adult farmers and preparing them for the more successful pursuit of their business. In other words, itinerant work in agriculture should not be dismissed from service until high schools for adult farmers are established in sufficient numbers to accommodate all who wish to receive more advanced instruction than that which the rural public schools afford.

The agriculture of Denmark is perhaps the most advanced of that of any country in the world. This position has been attained in the past forty years and is to be attributed more, perhaps, to the winter high schools for men and the summer high schools for women than to any other, or than to all other agencies combined. Admission to these schools is limited to persons over 18 years of age who have had experience in practical farming extending over at least one year. The five winter months are devoted to the teaching of men, and the three spring and summer months to giving instruction to women. Although Denmark is a country with a population of only two and one-half millions, and an area of about the size of Maryland and Connecticut combined, there are seventy-eight of these schools in operation, with an attendance of about 6,000 students. The schools are not devoted to the study of agriculture exclusively, but teach other branches of learning as well, with special attention given to the history and literature of Denmark, with a view to thereby stimulating the national spirit while improving the efficiency of the farmers in the various operations of agriculture. Out of the education given, and from the inspiration which these schools have imparted, there has grown up the wonderful system of cooperation by agricultural people that is unsurpassed for efficiency anywhere in the world.

A similar system is in operation in Sweden, introduced from Denmark, and is effecting equally satisfactory improvement among her rural people. In 1903 there were in that country 872 of these people's high schools for men and 636 for women.

With these successful examples before the educators of our own country, they would be failing in their duty to farming people if they did not at once make careful inquiry into the operation of these schools and ascertain whether such schools can not either in whole or in part be introduced into our system of education in the United States.

THE FARM CLUB.

There will never be the improvement in rural conditions in this country that is desired until there is first developed in the minds of the individual citizen in each community a sense of personal responsibility for such improvement. This can not be done by any system that does not recognize farm life in its social as well as in its economic aspects and relations; that does not provide in each community some fixed organization into which the better class of citizenship will come and around which the neighborhood life can be rallied in a social way for general improvement as well as for pecuniary advantages. So long as the farmers' institute is an agency operating from the outside, coming into a community and then going again, it will be largely only a temporary excitant, with but little of steadily persistent influence left to operate after it has gone. It must live in the community year after year as an active, intelligent agency in daily contact with the people whom it is to benefit. It must become a part of the community life, leading the way in all that relates to community betterment, as in roads, schools, churches, country-home improvement, and better farming. This can not be done by the organization of a single society for a county, but must be accomplished, if at all, through the community club.

Experience has shown that the average citizen will not, week after week and month after month, travel 10, 15, or 20 miles to attend meetings of farmers, however advantageous they may be, but is glad to be a member of a local club or society that includes his neighbors, if it proves useful and is within easy reach. It has been demonstrated also that the club that includes the entire family is far more efficient than where the members of the family are divided. Whatever advantage the separate club affords can be secured in the family club by having a men's section, a women's section, and a boys and girls' section, all held at the same time and place.

Clubs of this character not only promote the social side of country life and develop individual character, but they also provide centers in each community through which the agricultural people of the section can be promptly and directly reached with important information, and they can also be utilized in the education of their members in the best farm practice and for cooperation in carrying on much of the business of the community.

The Province of Quebec in Canada furnishes an example of the practical working of farm clubs when organized and encouraged by the State. The clubs in that province are incorporated, and have power to acquire and purchase lands for the purpose of holding exhibitions, for establishing agricultural schools or model farms, and may sell, lease, or otherwise dispose of them, but can not own more than 200 acres at a time. The clubs may own animals of improved breed, and keep such animals for service in the territorial district which the club occupies upon such conditions as the club may determine. They are "empowered to promote and favor experiments in farming, manuring, and improved agricultural machinery and implements; encourage the study of the best methods of fattening cattle, the production of milk, the manufacture of butter or cheese, and the improving and draining of lands."

The amount of annual subscription or dues of each member is $1. In 1907–8 there were 624 of these clubs in operation in the Province of Quebec, with a membership of 58,310. The receipts from the members were $113,572.40, and from the general government by way of grants in encouragement of agriculture, $26,644. Most of the clubs own standard breeds of stock. They bought high-bred animals in 1907 to the value of $17,590, and paid out $105,795 for improved seeds and fertilizers.

The principle involved in the club idea is that the many know more than the few, and that the many can do more than the few if they are organized for the work. The combined experience of a community expressed in the social meeting and worked out in a practical way upon one or more of the neighborhood farms starts many to thinking and acting who otherwise would have been content to have followed routine methods. Much of the lack of progress in the agricultural industry has been due to the isolated life that farmers lead, which has shut them off from personal contact with the more progressive and successful men of their own profession as well as from intercourse with wide-awake and advanced thinkers in other occupations. A well-organized farmers' club properly conducted soon interests the whole community in the general welfare and relieves the monotony of the old isolated farm life by introducing interesting and profitable pleasures among the people in the form of social entertainment and intelligent discussions.

The formation of farmers and their families into clubs for mutual improvement and business advantage is possible in every community, and experience has proved that the members of such associations are progressing in social refinement and in intellectual and business capacity far beyond their neighbors who have not availed themselves of such advantages. The farmers' institute is in position to take up this work. It is a legitimate part of its mission, and there is no other

agency to which the work can be committed that stands so high in public confidence or that has the force of men and the amount of financial and governmental support at command necessary for conducting it.

THE DEMONSTRATION FIELD.

The chief difficulty heretofore in convincing farmers of the value of methods differing radically from their own has been their distrust of the qualifications of the person recommending the change. If, however, the lecturer demonstrates his theory by actually obtaining the results predicted, and does it in the neighborhood in which those whom he wishes to convince reside, he has not only established the truth of the particular method advised, but has gained in addition the confidence and respect of the practical men and women of that community who are then prepared to accept other recommendations which he may make with faith in their ultimate success.

There can be no more conclusive proof of the value of a method than the results worked out successfully in the presence of those who are incredulous. A demonstration plat in a neighborhood which shows a marked increase in production over the customary methods of the community is an argument that can not be gainsaid.

The demonstration field and the feeding experiment do two things: They introduce, first of all, better methods, and, second, they put the people of a community into a teachable frame of mind to receive other truth not so readily demonstrable. Demonstration is a language that all can understand, and an argument which few can resist, especially if the methods are simple, such as the ordinary farmer can employ. More and more this form of teaching agriculture is being employed both in the higher institutions of learning as well as in the primary school and kindergarten, and wherever it is introduced there as an immediate improvement and increased interest on the part of those receiving the instruction.

In a recent report of a departmental committee on the subject of agricultural education in England and Wales covering 645 imperial octavo pages, and recording the testimony of 113 expert witnesses, the following statement is made in the conclusions of the committee:

> It was frequently stated by those giving evidence that farmers take more interest in experiments than in any other class of work undertaken by the colleges, and the committee agree that the teacher has no better means of getting into close touch with the farmer than by laying out for his inspection a series of experimental plats designed to elucidate some local questions.

The farmers' institute should call special attention to this most effective method of teaching agriculture, and in favored localities should go further and organize and conduct demonstration work of this character. Here is a field of effort of great possibilities almost unoccupied and very much needing development.

THE COUNTY STOCK BARN AND SEED FARM.

Another most important department of agriculture needing attention is the live-stock interest of the country. The difficulty that confronts farmers in many districts who wish to improve their stock is that of securing the services of well-bred sires. The country is full of cheap scrub horses, cattle, sheep, swine, and poultry. They are scrub because they have sprung from scrub sires. There can be no improvement in the stock of a community until well-bred sires are introduced and their services are available at rates low enough to be within easy reach of the farmer of moderate means.

Perhaps the most effective way of improving the stock of a country is by means of central stock barns where animals of approved breeds are kept for service. One such establishment in a county would be sufficient to create an interest in better stock throughout that county and would be a center from which breeding animals of standard quality could be distributed. If a portion of the original cost of the stock in such an establishment were advanced by the State, as is done in some foreign countries where stock breeding is successfully conducted, the balance could be contributed by the agricultural society of the county and the agricultural clubs.

The same difficulty that has interfered with the improvement of live stock exists in regard to procuring seeds adapted to local conditions. If a test farm were established in every county, the introduction of improved varieties of seeds and of suitable varieties of root, soiling, and fruit crops would become a comparatively simple matter. The tests would be made under local conditions and the results, if successful, would be accepted as justifying the farmers of the county in incurring the expense necessary to introduce the improved variety upon their farms.

FUTURE EXPANSION.

The fact that these extension methods are in the line of future progress makes it necessary that some agency shall take them up in a broad and effective way at once.

The time seems to have come for expanding the farmers' institute to include other forms of extension work than those heretofore embraced—for undertaking one or more of the following activities in addition to those already in operation: Organizing and sending out movable schools of agriculture; locating in each county a paid secretary of agriculture, who shall be an expert in agricultural science and practice; employing itinerant expert advisers to be stationed in each county; establishing demonstration plats and fields for exhibiting the results of the use of improved seeds, fertilizers, and methods of culture; organizing winter high schools of agriculture for adults;

organizing community farm clubs for social and business purposes; starting county stock barns in connection with the county agricultural societies; and seed farms for testing varieties of seeds, vegetables, and fruit trees in their adaptation to local conditions, and for distributing improved varieties among farmers.

The farmers' institute has undoubtedly been the chief instrument in the past in creating an interest in the present forms of agricultural education and methods for rural improvement. It should now equip itself for extending its usefulness to include advertising, organizing, and conducting these new and more advanced forms of itinerant instruction work.

Much of the work of this Office, in assisting in this work, should be in the direction of devising methods suited to extension conditions and to securing the cooperation of State and local educators in introducing them into their courses of instruction and into the everyday practices of the people. A large amount of money could annually be most advantageously applied to formulating courses of study and devising new methods of illustration suited to extension work and to demonstrating their value and adaptability to the various conditions peculiar to the several States.

It is both gratifying and encouraging to see the change of attitude that has occurred in recent years respecting the practicability of organizing and conducting in an effective way a system of agricultural education extension work. All educators, or almost all, are now thoroughly convinced on these points. As soon as, therefore, they can be brought to realize as well their individual responsibility for undertaking and carrying on this work, vigorous efforts in that direction will begin, and agriculture in this country will at once respond to the intelligent tillage which these efforts will secure, and our ability to supply all possible future demands for food for National support will be assured.

STATE REPORTS.

Numerous items of interest in the reports of the State directors are incapable of tabulation or are peculiar to a particular State, and at the same time are important to a complete record and understanding of the progress of the institute work as it develops each year. In order that the great body of institute workers may be familiar with this progress, the principal points are incorporated in the following narratives under the respective names of the States and Territories:

ALABAMA.

Institute director.—C. A. Cary, professor of veterinary science, Alabama Polytechnic Institute, Auburn.

During the year 51 sessions of institutes were held, with a total attendance of 8,244. There was also the annual summer school for

farmers continuing through 20 sessions, with an attendance of 507 persons. The leading topic assigned for discussion at the various institutes was along the line of the improvement of the live-stock industry with special reference to cattle-tick eradication. There was appropriated for institute work $600, not including the salary and expenses of the State director amounting to $400. The agricultural experiment station furnished 7 lecturers who devoted from twenty to thirty days each to giving instruction in the institutes.

Tuskegee Institute for colored people held meetings at the institution continuing for twelve days, with an average attendance of 50 persons. The expenses of these meetings are borne by the institution. The institute also sends out a traveling school of agriculture which goes to the plantations and gives instruction to the farmers, and also conducts demonstration work in illustration of the teaching. A conference agent is employed whose business is to go over the State and stir up interest among the colored people in agricultural education. The institute meetings are advertised by means of posters, postal-card notices, and by house-to-house visitation.

ALASKA.

Institute director.—C. C. Georgeson, special agent in charge of agricultural experiment stations, Sitka.

Farmers' institutes have not been held in Alaska, chiefly owing to the fact that the districts adapted to farming are widely separated and sparsely settled. Work of this character for the present is conducted by the special agent in charge of the agricultural experiment station at Sitka by correspondence and as he visits the various sections in the interest of his experiment and demonstration work.

ARIZONA.

Institute director.—R. W. Clothier, superintendent of farmers' institutes, Tucson.

During the past year 56 institutes were held, consisting of 56 sessions, with a total attendance of 2,673, at a cost of $1,745, which includes the salary of the superintendent. In addition to the regular institutes, a short course in agriculture was held at Thatcher, in which a lecture every day was delivered upon each of three branches of agriculture, and continued through a term of eight weeks. The total attendance was 111. The teaching was by the institute superintendent, assisted by three members of the experiment station staff. The expenses were borne by the experiment station out of the appropriation which provides for the expenses of the establishment of farmers' institutes and short courses of instruction throughout the Territory.

A feature of the institute work peculiar to Arizona is that of holding all of the institute meetings at night, and during the day the members of the institute force lecture in the neighborhood schools. In one instance the institute superintendent taught three classes in agriculture in a local academy regularly for a period of eight weeks. Each locality in which institutes were appointed was visited every two weeks and institute meetings held. Although 56 meetings were held at different times, the appointments were for only 22 different places.

ARKANSAS.

Institute director.—C. F. Adams, acting director agricultural experiment station, Fayetteville.

There were 56 institutes held in Arkansas during the past year. Fifty of these were one-day institutes, 4 were two-day, and 2 were three-day. The entire number of sessions was 64, and the attendance 5,596. The amount appropriated for institute expenses by the State was $1,500, of which $1,199.40 was expended. The instruction was given by members of the State agricultural college faculty and agricultural experiment station staff, who contributed fifty-six days of service. The director of the experiment station fixes the dates and places at which institutes are to be held. The principal subjects discussed were dairying, animal husbandry, and horticulture. There have been no county organizations in the State for holding institutes, and it has therefore been necessary for the State director to personally organize the meetings, and see that suitable arrangements are made for holding them. During the past year the director has organized a number of institute associations, and it is proposed to extend the organizations so as to cover all of the counties of the State.

CALIFORNIA.

Institute director.—W. T. Clarke, superintendent of farmers' institutes, Berkeley.

Institutes were held in California in 28 out of the 57 counties. The entire number of sessions was 294 and the attendance was 27,912. The State appropriated $6,000, and $2,000 additional was appropriated from the funds of the University of California for carrying on the work. There were 10 speakers on the State lecture force who contributed 100 days of service. There were 2 special institutes held; one at the university farm at Davis, and a general institute at the pathological laboratory at Whittier. These two meetings aggregated an attendance of 2,613. The interest taken in this State in this form of university extension in agriculture is daily becoming greater. At

the outset it was found necessary to solicit communities to receive the institutes. At the present time the demand is much greater than the means at the command of the university will enable it to meet.

Special stress has been laid upon the single-purpose institute continuing the meetings from two to six sessions, all of the sessions being devoted exclusively to one particular subject, treating it from various points of view. A number of viticultural institutes were held during the year which were of this character, and at which the subjects were discussed by authorities who likewise gave demonstrations in the vineyard—pruning the vines and performing such other operations as might affect the future crop. Poultry institutes were also held in which the subject of poultry rearing was discussed in its various phases by experts upon this subject. Creamery practice, sanitary milk production, horticulture in its various aspects, and cereal culture all received attention at institutes specially devoted to these particular topics. It is believed by the institute director that more good is done by institutes specially devoted to one topic than by those that are loaded down with half a dozen different subjects, with no special stress laid upon any one of them.

A demonstration train was equipped and sent out, consisting of 3 exhibition cars, 1 devoted to insect pests and the others to illustrative material, relating to cereal culture, sanitary milk production, veterinary science, plant pathology, viticulture, general horticulture, and the growth of hard-wood timber, special stress being laid upon the eucalypts. The train was accompanied by from 2 to 6 men from the college of agriculture acting as demonstrators. The stops varied from two to six hours.

COLORADO.

Institute director.—H. M. Cottrell, director of farmers' institutes, Fort Collins.

The most important movement in institute development during the year has been in conducting short courses continuing for one week in a locality. Twelve of these short courses for farmers and 5 domestic science short courses for women were held in as many different sections of the State. From 9 to 14 lecturers were sent to each farmers' short course, and 4 lecturers to each domestic science short course. In order to secure a farmers' short course 100 farmers had to agree to attend all of the sessions, and each was required to pay a tuition fee of $2. For a domestic science short course 50 women had to agree to attend and each pay a tuition fee of $1. The total enrollment for the 12 farmers' short courses was 1,401, and for the 5 domestic science short courses 1,034. The institute director is planning to hold 24 farmers' short courses and 10 domestic science short courses during the coming winter (1908–9). The expense of conducting institutes

during the year amounted to $7,724.46. Of this the State appropriated $5,000; fees were received from short-course students to the amount of $2,164; and the balance was from the State appropriation carried over from the previous year. Two railroad special train institutes were conducted, one as a feeder's special and the other as a potato special. These trains were run over 1,768 miles of territory and held 43 meetings, with a total attendance of 6,710.

CONNECTICUT.

Institute directors.—James F. Brown, secretary State board of agriculture, North Stonington; J. G. Schwink, jr., secretary Connecticut Dairymen's Association, Meriden; H. C. C. Miles, secretary Connecticut Pomological Society, Milford.

During the past year the three organizations responsible for farmers' institute work in Connecticut combined for conducting all of the institutes by appointing a board of managers composed of representatives from the board of agriculture, the dairymen's association, and the pomological society. This board planned the work of the year and assigned the various meetings to the different societies. Heretofore there has been little, if any, cooperation between these organizations in their institute work.

Under this arrangement the State dairymen's asociation held 20 institutes, composed of 43 sessions with a total attendance of 3,700, at an expense of $700. An annual convention of dairymen met in January, continuing through two days. Four field meetings were held by the association, one at the agricultural college and the other three by invitations of proprietors of dairy farms in different sections of the State. At these field meetings demonstrations and lectures were given and practical methods in the scoring of dairy products and in judging dairy herds were shown. These meetings were well attended, the number at each ranging from 200 to 600.

The pomological society held 5 one-day institutes, consisting of 2 sessions each. There were also 3 field meetings, with an estimated attendance of 1,100. At these field meetings, which are held in the summer months, practical demonstrations in orchard and small-fruit culture are given. The superintendent reports that they have found them fully as instructive and profitable as any of the winter institutes and are also as well attended. Four members of the agricultural college faculty and three from the agricultural experiment station contributed thirty-five days of service in giving instruction at the institute meetings. These speakers received no compensation except that their expenses were paid. The entire cost of the institutes last year amounted to $125.

DELAWARE.

Institute director.—Wesley Webb, corresponding secretary State board of agriculture, Dover.

There were held during the year 14 one-day institutes and 5 of two days, the whole composed of 52 sessions, with a total attendance of 3,905. The cost of the institutes was $725. The experiment station furnished five lecturers who contributed forty days of service. The principal topic discussed during the season was corn growing and breeding. Almost all of the instruction given was by members of the staff of the agricultural experiment station and by representatives from the United States Department of Agriculture. A field meeting of farmers held in June at the Delaware Agricultural College was attended by about 400 persons with very satisfactory results.

FLORIDA.

Institute director.—P. H. Rolfs, director of the agricultural experiment station, Gainesville.

Institute work was resumed in Florida under the direction of the agricultural experiment station. During the year 26 institutes consisting of 40 sessions were held, with an attendance of 3,316 and at an expense of about $2,400. In arranging for institutes, preference was given to counties where none had previously been held. The appropriation for institute work next year is $3,000. The dates, places, and programmes for the institutes are arranged by the superintendent in cooperation with local committees.

GEORGIA.

Institute director.—A. M. Soule, president agricultural college, Athens.

During the year the institute work was transferred to the direct management of the State college of agriculture and was conducted by members of the faculty of the college, assisted by three officials connected with the agricultural experiment station. A distinguishing feature of the work was the operation of an "education train." This train was out continuously for thirty-five days, made 150 stops, and the total attendance upon the lectures was approximately 150,000 persons. School children were invited to many of the meetings and attended in large numbers. In several instances the teachers required their scholars later to write essays relative to the exhibits carried on the train. A large amount of agricultural literature was distributed and addresses were made at the various stops. A wholesome sentiment was created throughout the State in favor of agricultural education, and the attention of the people was specially directed to the institutions where they could obtain information that would be

helpful. By means of this train all sections of the State were visited by the lecture force, and much information was collected respecting the local needs of farming people in the several districts.

The total number of institute sessions held during the year was 84, and the attendance at these regular institutes was approximately 10,000. There were also a number of picnics and harvest-home meetings held under the auspices of the farmers' institute force. The total cost of the institutes, exclusive of the train service, was about $4,000. No normal or round-up institutes were held during the year, but provision will be made for these during the coming season.

HAWAII.

Institute director.—William Weinrich, jr., secretary and treasurer farmers' institutes, Honolulu.

There were four farmers' institute meetings held in Hawaii, all of them at Honolulu, with a total attendance of about 150, and at a cost of $72.60. The difficulty experienced in institute work in Hawaii is that the meetings, owing to lack of funds for institute purposes, have been held in Honolulu, which is not the center of the small farming interests. Most of the small farming is done on the other islands, and it has not been practicable to send lecturers to these islands because of the insufficiency of funds for the purpose. The last meeting was held June 20 in Honolulu, and was attended by about 15 people. The most of these, however, were men having large interests in agriculture, and therefore represented a considerable territory, notwithstanding the small number present.

IDAHO.

Institute director.—H. T. French, director agricultural experiment station, Moscow.

Three county institute societies have now been organized in the State of Idaho, and there are a number of other local organizations which it is believed will develop into county associations. More time is being given to a single institute than formerly, the sessions being extended throughout a week or ten days. These long institutes are held in central locations, and are found to accomplish more, at least at the present stage of the work, than was possible at the shorter sessions. Twelve institutes were held during the year. Three of these continued through the long period. The total attendance at all of the sessions was 5,650 and the cost was $774.90. The institute lecture force is composed chiefly of professors from the agricultural college and members of the State experiment station staff. Four independent institutes were held with an estimated attendance of 500, and one railroad special was run over the Idaho branches of the

Northern Pacific, continuing through three days. About 2,000 people were met and over 8,000 copies of agricultural bulletins and pamphlets were distributed. Two women's institutes were held in connection with the regular institutes, with an attendance of from 60 to 125 women each day. The chief difficulty in the way of extending the work in Idaho is the lack of qualified speakers, the professors in the agricultural college and the members of the experiment station staff being fully occupied with their work at the college and station, and can scarcely be spared for exterior work, particularly since the distance to be traveled from the college to the lecture fields is so far that the time consumed in actual travel is greater than that occupied in lecturing at the institutes. There is need for a special force of institute workers to devote their entire attention, at least during the winter months, to giving instruction to farmers at their homes, and until such a force can be secured the number of institutes possible to be held will be quite limited.

ILLINOIS.

Institute director.—F. H. Hall, superintendent of farmers' institutes, Aurora.

Institutes were held during the past year in a larger number of places than ever before. In one county there were eight days of institutes in 3 towns; in another, six days in 4 towns. In each of several counties there were four days in 2 towns. The institute officers and the officers of the domestic science association have devoted considerable attention to encouraging young people to attend the two-weeks course in agriculture and the course in household science at the university. As a result of these efforts, the attendance at the short course last year was larger than in any previous year. Seventy-five of the 102 counties were represented and 552 students were enrolled.

In many instances institute speakers have been invited by county superintendents and city superintendents and teachers to address the high schools in the towns in which institutes have been held, and in other instances high-school pupils and their teachers have accepted the invitation to attend one or more sessions of the institutes. A county farmers' institute was held in the buildings of one of the State normal schools. This was, in fact, the district institute attended by prominent men and women from at least six counties and by prospective teachers from every county in northern Illinois. So great was the interest aroused in this institute that those in attendance voted unanimously to hold the next institute at the normal school, and as an outcome of the success of this meeting it has already been planned that there shall be a farmers' institute at each of the five State normal schools next year. In this manner it is hoped to bring about 2,000 prospective teachers and several hundred actual teachers into contact with the farmers' institute, and it is believed that the normal-school

farmers' institute will become an important and prominent factor in promoting and maintaining a sympathetic and helpful relation between the college of agriculture and experiment station on the one hand and the common schools on the other.

A press bureau was established through which there were prepared and sent out to upward of 500 newspapers, 62 articles. More than 200 of these papers published the matter sent out. These articles were for the most part reports of institute addresses and contained much important agricultural information. For the year ended June 30, 1908, 627 institute sessions were held with a reported attendance of 122,523. There were two hundred and sixty days of institutes. Two hundred and thirty-three of these were addressed by college and experiment station speakers, seventeen by speakers from the State entomologist's department, and one hundred and four by speakers from the State highway commission. The total expenditure for institute purposes, including the salaries of the superintendent and secretary, from appropriation to the State institute, appropriation to the counties, amounts received from county boards of supervisors, and amounts paid in by local subscribers, was $30,097.99.

INDIANA.

Institute director.—W. C. Latta, superintendent of farmers' institutes, Lafayette.

The special features of the institute work for the past year were: (1) Women's sessions, of which 67 were reported from 32 counties of the State; a few of these were separate sessions. (2) Special sessions for boys and girls, 27 of which were reported from 20 counties; a number of these were corn sessions especially for boys. (3) Educational sessions, 30 of which were reported from 18 counties. At these sessions rural school improvement, industrial training, and agricultural education were discussed. (4) Special sessions for the discussion of soil, corn, melon, and tomato growing.

Dairy and live-stock topics were presented at meetings held in considerable numbers of counties. Instruction in domestic science had been a prominent feature of the institute work for the last four years, in which time all but seven of the counties of the State have been visited one or more times by specially trained domestic science instructors.

An effort was made to organize the boys and girls into school clubs in order that they might thus better prepare for the various tests to be held under the auspices of the farmers' institute association. Very little was accomplished, however, in the actual work of organizing the school clubs, but it is believed that a number of such clubs will be organized in the near future. An earnest effort on the part of the

general committee in charge of the institutes and of the speakers assigned was made to introduce object lessons, demonstrations, and the results of practical experience in the discussion of the so-called practical subjects under consideration at the institutes. An effort was made with some degree of success to introduce the method of the schoolroom more fully into the institute work, and it is believed substantial progress was made in this direction. The total attendance at the institutes during the year was 195,912. Three hundred and twenty-one institutes were held, composed of 1,112 sessions. The cost of the institutes is estimated at about $17,000. Thirty-seven independent institutes were held, and a conference continued through 6 sessions, and a normal institute of 10 sessions, with an attendance of about 130, were also held. Five lecturers for institute work were provided by the agricultural college and 4 by the agricultural experiment station.

IOWA.

Institute director.—J. C. Simpson, secretary State board of agriculture, Des Moines.

Farmers' institutes in Iowa are held independently of each other, there being no central board or institute director in control of the work. The law provides that any county may secure State aid not to exceed $75 in any one year by holding two-day sessions of institutes with an attendance of at least 40 persons at each session. During the past year 75 two-day institutes were held with an approximate attendance of 75,000, and at a cost of $7,954.98. Five of the professors from the State agricultural college assisted in county institutes as lecturers.

During the month of December there was held a State agricultural convention and corn show in the agricultural rooms at Des Moines, which was well attended.

KANSAS.

Institute director.—J. H. Miller, superintendent of farmers' institutes, Manhattan.

The year's institute work opened and continued with more than ordinary interest, although the attendance at many places was not as large as for the previous year. The most marked feature, however, was the decided interest of the best farmers of each community. In earlier years the leading farmers regarded the institutes with some suspicion. Now they are recognizing these meetings as of great practical value for the advancement of the agriculture of the State. One hundred and seventy-six regular farmers' institutes were held with an attendance of 33,684. Eleven speakers were furnished by the college and experiment station, who gave a total of one hundred and

ninety days of service and made 588 addresses. The local speakers numbered 957. Nine summer meetings, picnics, and Chautauquas were held which were attended by college speakers, at which there were 5,650 hearers. On account of railroad legislation reducing rates, and consequent inability of railroads to furnish transportation for speakers, no educational trains were conducted this year. The number of new institutes organized was 35, which makes the total number of institutes in Kansas 192. The total attendance at the summer meetings and regular institutes was 41,334. The institute department was also represented at 31 teachers' institutes, and 9 county and district teachers' associations. The State farmers' institute held its second annual meeting at Manhattan during the Christmas vacation. There was an enrollment of 384 in attendance, 312 being boys, delegates from the boys' corn contests. The attendance at the State convention held at the college during that week aggregated over 1,000.

KENTUCKY.

Institute director.—M. C. Rankin, commissioner of agriculture, Frankfort.

At least one institute meeting was held in every county in the State during the year, the entire number being 132, composed of 514 sessions, at which there was a total attendance of 21,690. There was also a round-up institute consisting of 8 sessions, with an average attendance of 500 per session. Many new farmers' clubs have been organized during the year, and a large number of institutes were located in parts of the counties other than at county seats, where they had previously been held. An effort has been made to secure the organization of a farmers' club in every magisterial district in every county in the State. The State farmers' institute was held at Frankfort with the largest attendance and the greatest interest ever before shown at a State institute meeting. The State agricultural college and the agricultural experiment station contributed the services of five of their members for lecturing at the institutes. A report of the proceedings is published annually in an edition of 25,000 copies, which is distributed by mail and through the officers of county farmers' clubs.

LOUISIANA.

Institute director.—Charles Schuler, commissioner State board of agriculture and immigration, Baton Rouge.

No institutes were held in Louisiana during the past year, although an appropriation of $2,000 had been made by the legislature for the purpose. Inasmuch as the other duties of the commissioner require his entire time and attention, application was made to the State legislature for an assistant to devote himself to the management of the farmers' institutes of the State. The bill failed to become a law,

and consequently the institute work was suspended. Application has again been made for an institute conductor and for a more liberal appropriation for carrying on the work, which, if granted, will enable the department to reorganize the institutes and again carry on this important branch of the department's work.

MAINE.

Institute director.—A. W. Gilman, commissioner of agriculture, Augusta.

The farmers' institute work of the year in Maine has been very successful. Two institutes were held in each county, and the remainder of the funds was apportioned among the counties according to the extent of the agricultural interests. Most of the institutes were held consecutively during the late autumn and the late winter. The institute force consisted of two speakers from outside of the State and one or two who are residents. These lecturers were frequently assisted by local speakers. Two sessions were held at each institute, as a rule. In some localities special independent meetings have been conducted, and at Auburn a State dairy conference continuing for three days was held in December.

Fifty regular institutes consisting of 92 sessions were held during the year. The total attendance at all of the sessions was 14,143. The average per session was 145. The annual appropriation for institutes and for the dairy conference is $3,000, not including the salary and expenses of the director, which is $2,000 additional. Twelve independent institutes were held in connection with farmers' clubs and granges. A brief summary of the institute work of the year is published annually in the report of the department of agriculture, 6,000 copies of which are printed and distributed through the members of the legislature, the agricultural societies, granges, farmers' institutes, and other agricultural organizations.

MARYLAND.

Institute director.—W. L. Amoss, director of farmers' institutes, Benson.

A private car with Pullman equipment was purchased, which was run over the Maryland and Pennsylvania railroads for a period of twenty-four days. One-half of the coach was equipped as a lecture hall, seating 50 persons comfortably. Classes were registered in the various localities at which stops were made and the members were given free tickets for two short courses of six lectures each. The morning session was devoted to answering questions, inspecting farmers' orchards, dairies, and rendering assistance that might be requested by persons living within driving distance of the institute. Special sessions for women were held in connection with these schools, and also a boys' session at each institute. There were registered at

the institute schools 1,714 persons. The interest manifested was very satisfactory and the outlook for work of similar character in the next year is very hopeful. Forty-one institutes were held, composed of 117 sessions, with a total attendance of 8,903. The entire cost of the work, including the equipment of the movable school, was $6,000.

One institute for colored farmers was held with an estimated attendance of 375. The movable school did much valuable work directly through the patrons who registered in the classes agreeing to attend all of the sessions, and indirectly through meeting farmers who visited the car for expert advice and who were helped by personal visits to their farms, orchards, stables, etc.

MASSACHUSETTS.

Institute director.—J. L. Ellsworth, secretary State board of agriculture, Boston.

Owing to the increased appropriation for institute work, more meetings were held than during previous years. There were 69 speakers on the State force of institute lecturers. The selection of the speakers and the subjects to be discussed are left to the local people, except that occasionally suggestions are offered by the office of the board. Eight members of the faculty of the agricultural college and five of the staff of the State agricultural experiment station were on the list of lecturers.

The local agricultural societies are responsible for the institute work in Massachusetts, and every county in the State has at least one of these societies, while most of them have several, there being no less than eight agricultural societies in Worcester County. Institutes are furnished to other agricultural organizations where the territory which they cover is not embraced by a regular agricultural society and where their line of work is specialized to such a degree that it can be better covered at their meetings than at those of the agricultural societies. As, for instance, in the case of the Massachusetts Fruit Growers' Association and of the various bee keepers' associations. During the year 156 sessions were held, attended by 18,426 persons. The average attendance was 118, and the amount expended in carrying on the work was $1,877.26.

MICHIGAN.

Institute director.—L. R. Taft, superintendent farmers' institute, East Lansing.

During the past year county farmers' institutes have been held in 66 counties in Michigan, and with few exceptions they were continued for two days. One-day institutes were held in 63 counties. Besides the regular institutes a large number of special meetings have been held relating to sugar-beet growing, live-stock husbandry, etc. In con-

ducting the regular institutes the local arrangements are left almost entirely to the county institute society officers and to the vice-presidents acting as local managers for the one-day institutes. The attendance in nearly every case was all that could have been desired. In a large number of instances the halls were filled and many were turned away. The total attendance during the year reached 135,000, or about 14,000 more than in 1906–7.

In selecting lecturers for the farmers' institutes the officers of each county society are requested to furnish a list of topics which they wish to have discussed, and speakers are then procured who are specially fitted for discussing these topics. In most of the counties the cooperation of the county superintendent of schools has been secured and is attended with most satisfactory results.

In a large number of instances a speaker has been furnished by the county commissioner, paid from the school funds for the afternoon and evening sessions of the one-day institutes. During the forenoon and the early part of the afternoon the speaker thus furnished visits, with the local commissioner, schools in the districts where the institutes are being held and addresses the scholars upon educational matters in the afternoon and also in the evening. One State speaker is furnished from the farmers' institute force for a one-day institute, and it is expected that one local speaker will be supplied for the morning and afternoon sessions as well as one for the evening. As a rule, the topics of the forenoon and two of the afternoon sessions relate to practical farming, but not infrequently those in the afternoon and one or two in the evening are along educational lines. For two-day meetings it has been customary to send at least three State speakers, one of whom has generally been a woman.

The third annual normal institute was held at the college in November. The meeting was attended by practically all of the institute lecturers. The time was spent in discussing methods of conducting the institutes and in listening to lectures and addresses by the college faculty. A special institute train was run for three days upon the Pere Marquette road and six days on the Michigan Central Railroad, making 54 stops. These stops at the different stations varied from one hour to an hour and fifteen minutes. Thirty to forty minutes of the time were taken up by the lectures in the coaches, and the remaining portion was given to the examination of the exhibits in the baggage cars. The exhibits included samples of seed corn of different varieties, seed testers, spray pumps, spraying solutions, samples illustrating grafting, budding, and pruning; milk tester, forage plants, grasses and grains, charts, and diagrams. There was also a very interesting exhibit of road-making materials, with drawings and photographs of State roads under construction. Much interest was also shown in the exhibit of commercial fertilizers.

The thirteenth annual round-up farmers' institute was held at the agricultural college in February. Among the special features were the forestry session, the agricultural sessions, the live stock session, and the dairy session.

Nine hundred and sixty-nine sessions of regular institutes were held during the year, with an attendance of 121,654. The round-up institute consisting of 11 sessions, with a total attendance of 5,390, and the normal institute consisting of 10 sessions, with a total attendance of 260 lecturers, were held. Independent institutes were held in a number of counties, and also a great number of picnics, harvest-home meetings, etc. The total cost of the institute work for the year was $8,443.51, including administration and office expenses and the printing and mailing of 10,000 copies of the 300-page institute report. The actual cost of holding the regular institutes has been about $3 per session at the one-day institutes and $10 per session for two-day institutes. This means about $7 for the one-day institute and $50 for the two-day institute.

MINNESOTA.

Institute director.—A. D. Wilson, director of farmers' institutes, St. Anthony Park.

During the past year the institute director has been engaged in organizing farmers for cooperation in producing farm crops. A corn club, a potato club, a cow-testing association, and a number of clubs of similar character have been formed at different places. The farmers of the corn and potato clubs are working together to produce one special variety of these crops instead of each farmer producing a different variety, and all are striving by cooperation to improve the variety, and also improve their marketing conditions. One county, Meeker, has been thoroughly organized, 16 township organizations having been formed and a central organization, all cooperating in improving agricultural conditions in that county. They have already formed a stock-shipping association to handle live stock grown by the members of the county clubs, and are considering the formation of a cooperative packing company to take the place of the shipping association.

Twelve articles on subjects of interest to farmers have been prepared and sent to 450 of the local papers in Minnesota, requesting them to publish one article each month during the coming year.

Two hundred and seventy-two institutes were held during the year composed of 547 sessions with an attendance of 92,091. The amount expended for institute purposes, including the publication of the institute annual, amounted to $20,454. Twenty-three independent institutes were held, with an attendance estimated at 4,600. Thirty-seven women's institutes were held during the summer in connection

with the regular institutes. The new features that have been introduced, to the perfecting of which special attention is being given, is the organization of cooperative clubs and the furnishing of agricultural literature to county papers.

MISSISSIPPI.

Institute director.—E. R. Lloyd, director of farmers' institutes, Agricultural College.

At the last session of the legislature the appropriation for institute work was increased $2,000 per year, making the funds now available for this work $5,000 annually, exclusive of the director's salary. A law was also enacted by the State legislature making it possible for each county in the State to establish and maintain a county agricultural high school. As soon as a county complies with the law establishing the school, the State will appropriate annually to each school $1,000. The farmers' institute was an important factor in creating a public sentiment in favor of these schools, and the institute department also cooperates with each school by furnishing lecturers, corn judges, bulletins, etc. The institute has assisted the schoolboys' corn club movement and is cooperating with these clubs as far as possible. Clubs are now organized in about forty counties. Each county club exhibited at the State fair this year, and their exhibits were the most attractive features of the fair.

In former years one of the greatest difficulties in Mississippi was getting the farmers sufficiently interested to attend the meetings. This has largely disappeared, and now the difficulty is to get enough money and men to hold the institutes that the farmers are demanding. During the year 129 institutes were held with a total attendance of 28,910. The amount expended in institute work was $3,000, not including the director's salary. Five independent institutes were held, with an estimated attendance of 510, and a round-up institute continuing through eight sessions with an attendance of 970.

MISSOURI.

Institute director.—G. B. Ellis, secretary State board of agriculture, Columbia.

Eight hundred and seventy-five sessions of institutes were held in Missouri during the year, with an attendance of approximately 40,000 persons. The appropriation for institute purposes by the State is $5,000. The work is under the direction of the secretary of the State board of agriculture. Five independent institutes were held, with an attendance estimated at 2,000, and ten sessions of a round-up institute, with an attendance of 8,000. A seed and soil special train was also operated. Five boys' encampments were held,

and also a housekeepers' conference. Fourteen members of the agricultural college faculty and experiment station staff contributed one hundred and twenty days of service as lecturers.

MONTANA.

Institute director.—F. B. Linfield, director agricultural experiment station, Bozeman; F. S. Cooley, superintendent of farmers' institutes, Bozeman.

Seventy-two institutes were held in Montana, with a total attendance of 12,293, at a cost of $7,500. Thirteen agricultural college and experiment station lecturers were upon the institute force. In addition to the regular institute meetings, a special dairy train was run across the State, continuing two weeks and making twelve stops. Plans are being formulated for the coming season to introduce agricultural and vocational lecture courses into the high schools. A number of high schools of the State have applied for courses of this character. A number of dry-farm demonstrations have been held for illustrating the possibilities of dry-land cropping under various tillage methods. Plans are also being perfected for the inauguration of movable schools of agriculture and domestic science.

NEBRASKA.

Institute director.—E. A. Burnett, director agricultural experiment station, Lincoln; Val Keyser, assistant superintendent farmers' institutes, Lincoln.

The new work taken up by the department of farmers' institutes in Nebraska for the past season was a short-course, or farmers' institute, school. This was held at Pawnee City in place of the regular farmers' institute. Three courses of instruction were offered, and lectures in these courses were given each forenoon of the week, supplemented by demonstrations for the afternoon sessions. The officers of the farmers' institute were authorized to take charge of the school, which was held during the week of February 10 to 15. A course of instruction was given in feeds and feeding, with judging demonstrations each afternoon, using beef cattle and hogs. A course of instruction in soils and soil problems was also given. Soils collected in Pawnee County were used for this work. There was also a course of lectures for women on foods, cooking and serving, with demonstrations for each lecture.

The total attendance of the school was 120, although no special effort had been made to get a large attendance.

The department made a special effort last year to encourage the work of women in farmers' institutes. Three women speakers were employed throughout the season. Much interest was manifested, and about 40 counties organized women's auxiliaries. The institutes as a whole were much better attended than in previous years, and

interest was taken in all phases of the work. The total number of regular institutes held was 175, composed of 602 half-day sessions, with a total attendance of 93,824. The amount appropriated for institute purposes was $13,617. Thirteen members of the State agricultural college and experiment station staff participated in institute lecturing. One normal institute was held at Lincoln, continuing from October 28 to November 2, for the instruction of the lecturers. Some of the older institute points held sessions with local talent without the assistance of the State speakers. A farmers' institute convention was held January 24, 1908, in connection with the meetings of organized agriculture, and about 300 local institute managements attended. Fourteen boys and girls' institutes were held in addition to the regular institutes, with a total attendance of 4,125. Three bulletins treating the subject of corn culture were furnished the boys during the season. A short course, continuing for six days, was held, attended by 60 men and 60 women. Four teachers were employed in giving instruction. Two of these were from the agricultural experiment station staff.

NEVADA.

Institute director.—J. E. Stubbs, president Nevada State University, Reno.

No institutes were held in Nevada during the year.

NEW HAMPSHIRE.

Institute director.—N. J. Bachelder, secretary State board of agriculture, Concord.

Institutes were held in every county in New Hampshire with one exception. The entire number was 16, and the number of sessions 32, with a total attendance of 2,500. The amount appropriated for institute purposes was $1,000, of which $900 was expended. One thousand five hundred copies of the proceedings were printed and distributed.

NEW JERSEY.

Institute director.—Franklin Dye, secretary State board of agriculture, Trenton.

Thirty-seven farmers' institutes were held in New Jersey during the past year, composed of 120 sessions, with an attendance of 10,154 persons. Special institutes consisting chiefly of demonstration work in dairy cattle and barn architecture were held, at which the interest on the part of the farmers and dairymen, who attended in large numbers, was very pronounced. The general lines of instruction in the institutes were soils, fertilizers, green crops for soiling and for fertilizing, the various crops best to grow, methods of cultivation and marketing, seeds, dairying, poultry, fruit production, market gardening, etc. The total cost of the institutes was $2,500.

NEW MEXICO.

Institute director.—J. D. Tinsley, superintendent farmers' institutes, Agricultural College.

Farmers' institute meetings were held in 17 of the 25 counties. There were 68 sessions, with an attendance of 685 persons, as against 28 sessions and 969 in attendance the previous year. The local-society plan of organization is being continued, but it is found difficult to get the people to hold meetings regularly. The Territory appropriated nothing directly for institute purposes, but the expenses have been paid from funds appropriated by the Territory for support of the college. The dates and places for holding institutes are arranged by the superintendents, and the programmes by the local committees or farmers' institute societies.

NEW YORK.

Institute director.—R. A. Pearson, commissioner of agriculture, Albany.

In the season of 1907–8, 307 regular institutes were held in New York State. These comprised 1,471 sessions, which were attended by 149,418 persons. The work was conducted under an appropriation of $25,000. There were held also 9 separate bee-keepers' institutes, 7 special poultry institutes, and 23 special women's institutes. At most of the regular institutes there was one speaker in attendance as a representative of the department of education, who spoke upon the subject of rural education. Throughout the season at least one and frequently two experts were in the field representing the State experiment station at Geneva and speakers from the staff of the State agricultural college assisted as their class work permitted.

As usual, the regular institute season was started with a normal institute, which was held at Cornell University. At that meeting the institute workers heard lectures from well-known agricultural scientists and received these lectures also in printed form. They also had a review of the work done in experimental lines during the previous year. The farmers' institute fund was drawn upon also to assist at annual meetings of some of the agricultural organizations.

One of the most successful innovations of the institute work this year has been the holding of county conferences prior to making institute plans. A conference was held in each county, attended by presidents of agricultural organizations, masters of granges, and institute correspondents. These persons were told how many days' work could be done in their county, and they recommended places at which meetings should be held, duration of meetings, and subjects for discussion. These conferences undoubtedly have resulted in increased interest and attendance at the institutes during the past year.

NORTH CAROLINA.

Institute director.—W. A. Graham, commissioner of agriculture, Raleigh.

Institutes were held in all of the counties of North Carolina excepting three. There were in all 423 sessions. One hundred and fifty-four of these were sessions for women. The total attendance was 40,350 men and 12,628 women. The total cost of the institutes was about $7,500. A round-up institute continuing through 8 sessions was held, with an attendance of 400 persons. The experiment station ran a corn train, continuing for about ten days. The success of the women's institutes was pronounced, indicating that the way is open in the Southern States for the introduction of institutes for women as soon as a sufficient number of capable lecturers can be secured to give instruction.

NORTH DAKOTA.

Institute director.—T. A. Hoverstad, superintendent of farmers' institutes, Fargo.

Ninety institutes were held during the year. Eighty-one of these were one-day meetings, 8 two-day, and 1 four-day. In all, 233 sessions were held, and there was a total attendance of 38,000 people. There were, as a rule, three lecturers at each meeting. The interest in the institute work is growing rapidly. The institute force is endeavoring to find out the problems that the farmers are most interested in with a view to preparing programmes for the discussion of these questions. Last year special effort was made to interest the farmers in a system of farming that would produce a large crop each year and at the same time leave the land in good condition for the succeeding crop. It is believed that considerable interest was awakened in this subject and that material improvement will result from its discussion. Twelve independent institutes were held, besides a grain-growers' convention, a good-roads convention, and a domestic-science meeting. Interest in women's institutes has increased. During the year two were held, at which the interest and attendance were quite gratifying.

OHIO.

Institute director.—T. L. Calvert, secretary State board of agriculture, Columbus.

During the institute season of 1908, 298 institutes were held, representing 1,490 sessions, and a total attendance of 461,515. The amendment to the farmers' institute law of March 31, 1906, permits the State board of agriculture to aid not more than four institutes in each county, and further provides for an assessment on each county of $250, one-half to go to the State board of agriculture for per diem and ex-

penses of speakers, and the remainder to be divided among the 4 institutes for the purpose of defraying local expenses. Of the 88 counties, 21 did not avail themselves of the opportunity of procuring their full quota. Twenty-seven counties, on the other hand, requested more than could be granted them according to law. Twenty-three independent institutes were held during the season, with an estimated attendance of 9,320.

OKLAHOMA.

Institute director.—T. M. Jeffords, superintendent of farmers' institutes, Guthrie.

Governmental conditions in Oklahoma during the past year have been in a somewhat chaotic stage. During that period the State was passing from Territorial organization to that of statehood. The constitutional convention divided many of the counties in older Oklahoma and created 40 new counties on the Indian Territory side of the line. The first legislature in session passed an act, approved March 2, 1908, creating the State board of agriculture. Under its provisions the board of agriculture was given entire jurisdiction over the system of farmers' institutes within the State, and the sum of $3,000 was appropriated for the purpose of organizing farmers' institute work in the new counties. A superintendent of institutes has been selected and placed in personal charge of this work under the direction of the board, and a comprehensive programme for the ensuing year has been mapped out. The counties under this programme will be divided into groups in such manner that one set of lecturers can cover a group in ten days or two weeks. The superintendent recommends that a two-day institute be held in each county at the most available point; the first half day to be devoted to agricultural demonstration in judging stock, corn, cattle, etc., the afternoon of the first day to take up the regular programme of the institute, and in a separate room there will, at the same time, be conducted a class for boys in corn and cattle judging, and also be given practical demonstrations to teachers of how to teach agriculture and domestic science in the schools. The night sessions are to be of a general character of interest to farmers, business men, and teachers. A stereopticon will be used to illustrate evening lectures. No regular institutes were held during the past year owing to the change from Territorial to State government above mentioned.

OREGON.

Institute director.—J. Withycombe, director agricultural experiment station, Corvallis.

The management of farmers' institutes in Oregon has been placed under the direction of the board of regents of the agricultural college.

By their direction a committee of three from the experiment station staff has been selected to conduct the institute work. Thirty-two institutes were held, composed of 79 sessions, with an attendance of 7,500. The agricultural college furnished two speakers at each institute, and four members of the agricultural experiment station staff participated in the instruction work. A demonstration train was run through the Willamette Valley which made 17 stops, at which meetings were held and addresses given. The total attendance upon these demonstration trains was about 3,000.

PENNSYLVANIA.

Institute director.—A. L. Martin, deputy secretary of agriculture, and director of farmers' institutes, Harrisburg.

In addition to the 217 regular institutes, there were held 4 movable institute schools which continued for four days. At these schools the subjects of dairying, dairy husbandry, etc., as relating to barn and stable management, feed, light and ventilation, proper sanitary conditions for handling milk, milk testing by Babcock test was quite thoroughly considered by the classes. Horticulture in its various lines, such as orchard location, varieties, planting, pruning, thinning of fruit, spraying, etc., formed a portion of the class work upon this subject, and in the poultry industry there were treated the subject of breeds, proper housing, food, egg production, and preparation for market. Requests for schools of this character have come in from most of the counties of the State. The number of sessions of general institutes held was 989, and the total attendance 145,353. The appropriation for institute purposes amounted to $23,000. Eight lecturers from the faculty of the agricultural college and two from the staff of the experiment station were employed in giving instruction. Seven independent institutes were held with an attendance of 8,665, and 1 round-up institute continuing through 9 sessions with an attendance of 2,500. The total attendance at the special institutes and movable schools was 2,200, and at the farmers' picnics 24,000. At all two-day institutes one session was devoted to women's work, over which a lady was expected to preside, and a programme suited to the discussion of this topic was carried out. Eight thousand copies of an abstract of the proceedings of the institute are printed and distributed through the regular mailing list of the department of agriculture.

PORTO RICO.

Institute director.—D. W. May, special agent in charge of agricultural experiment station, Mayaguez.

In Porto Rico no institutes were held last year. The work of giving instruction in a peripatetic way to the farmers of the island

is in the hands of the experiment station staff. The officers of the experiment station for the present find it more effective to visit the planters from time to time and give practical demonstrations at their homes.

RHODE ISLAND.

Institute director.—John J. Dunn, secretary State board of agriculture, Providence.

Fifteen institutes were held in the State during the year, with a total attendance of 1,800. The total cost of the institutes last year was $125, not including advertising and the salary of the State director. No special appropriation is made for institute purposes, but the board of agriculture sets aside each year from the $20,000 which it receives from the State so much as may be necessary for meeting institute expenses. Five members of the agricultural college faculty and two members of the State experiment station staff were employed in giving instruction.

SOUTH CAROLINA.

Institute director.—D. N. Barrow, professor of agriculture, Clemson College.

Owing to the fact that the farmers' institute work in South Carolina is paid for out of the income of Clemson College, and as the college has had numerous improvements under way in the constructing of large dormitories and other necessary buildings, only a small amount could be appropriated for carrying on farmers' institutes. Eighteen counties, however, were visited, and several institutes were held in each county. These meetings were attended by 13,392 farmers. During the spring of 1907 the Southern Railway gave the college the use of two cars, one a baggage coach and the other a day coach. The large baggage coach was used for the display of material illustrating the work of the various departments of the college and experiment station. Exhibits were made by the horticultural division, the entomological division, the chemical department of the college, and the agricultural division. Thirty-five places were visited upon the trip, and between 12,000 and 15,000 people inspected the exhibits. Experts from the agricultural college and the experiment station accompanied the train and delivered lectures upon agricultural subjects and explained in detail the character and practical value of the several exhibits.

SOUTH DAKOTA.

Institute director.—A. E. Chamberlain, superintendent of farmers' institutes, Brookings.

Farmers' institutes in South Dakota are under the control of a committee of the board of trustees of the agricultural college, who

conduct the work through a superintendent of institutes whose headquarters is at Brookings. The institute superintendent devoted a considerable part of the period in which no institutes were held to sending out letters of instruction relative to the selection of seed and to the cultivation of corn. Accompanying each of these seed-corn letters was a circular requesting the recipient to select some of his best corn for exhibit at the National Corn Show, held in Chicago in October. As a result of this the State was creditably represented at that exposition. Over 5,000 bulletins upon scab in sheep, internal parasites, and other subjects of interest were mailed from the office to stock raisers throughout the State. Twelve thousand fruit lists, with instructions for buying, planting, and selecting fruit trees, were printed and distributed. The institute season opened September 17, 1907, and closed March 23, 1908. Meetings were held in 86 towns. Other meetings had been appointed, but for various reasons could not be held. There were 29 one-day institutes, 55 two-day, and 2 three-day. The total number of sessions was 290, and the attendance at the meetings 43,560. The total cost of the institutes was $6,995. The appropriation for the coming year is $7,000. Two members of the faculty of the agricultural college contributed 265 days of service as lecturers. There was one independent institute held, with an attendance of about 400. One of the instructors in the domestic science department at the college at Brookings accompanied the corps of lecturers and gave instruction, usually at the general meetings, but in a number of instances in separate halls, and to ladies exclusively. The institute superintendent has arranged for holding a number of schools, continuing for three days, devoted to stock and corn judging. These are intended to be self-sustaining through contributions by the community in which the schools are held and from membership fees.

TENNESSEE.

Institute director.—John Thompson, commissioner of agriculture, Nashville.

Institutes were held in Tennessee in all of the counties excepting 12. The total number of one-day institutes was 81, and 3 three-day. The number of sessions is reported at 186, and the total attendance at 18,915. The cost of the institutes for the year was $4,300, not including the salary and expenses of the State director, which would increase this amount by $2,800. Two members of the State agricultural experiment station staff lectured at the institutes and contributed eighty-four days of time. Three round-up institutes were held, composed of 24 sessions, with an attendance of 5,500.

A women's auxiliary to the farmers' institute was organized at Knoxville May 29, 1908. An abstract of the proceedings of the

round-up institute is published in a biennial report by the commissioner of agriculture, and is distributed by mail upon application to the commissioner.

TEXAS.

Institute director.—E. R. Kone, commissioner of agriculture, Austin.

The thirtieth legislature of Texas in organizing the department of agriculture provided that the commissioner shall "encourage the organization of agricultural societies, and for the benefit of the agricultural communities shall cause to be held farmers' institutes at such times and at such places throughout the State as will best promote the advancement of agricultural knowledge and the improvement of agricultural methods and practices. He shall publish and distribute such papers and addresses read or delivered at these institutes as he shall deem to be of value to the farming interest." Under this act the commissioner held 36 one-day institutes between November 22, 1907, and May 18, 1908. No record was kept of the attendance. The total cost is given at $382.25. No specific appropriation has been made for institute work, but the expenses are paid from general funds that are appropriated for dissemination of agricultural information. Two members of the college faculty and three of the experiment station staff lectured at the institutes, contributing twenty-one days of time. This law is the first statutory provision in recognition of the farmers' institute work in Texas. The conditions imposed by the board of agriculture upon which institutes can be held are, first, that no institute shall be held at any place unless a request is filed for such an institute with the commissioner of agriculture. Second, there must be some local organization in the community that will be responsible for the preliminary arrangements necessary to hold the institute. Third, where no such local organization already exists the organization of a body of farmers, with a president and a secretary, for the purpose of arranging for an institute is all that will be required. The officers of the local organization are expected to advertise the date of the institute by means of the local papers and by handbills posted in conspicuous places, and are to meet such expenses as may be necessary for hall rent, janitor services, etc.

UTAH.

Institute director.—Lewis A. Merrill, superintendent of farmers' institutes, Salt Lake City.

A new feature of the institute work in Utah inaugurated during the past year is the farmers' school held in different localities continuing during five days, not more than one of these schools being held in any one county. At these schools a registration fee is charged and the

locality must furnish rooms for holding the school as well as provide light and heat. As a result of the experiment there have come already applications for a number of similar schools to be held during the coming season. Eleven of these schools were held during the year. There were also 14 regular institutes, 4 continuing one day and 10 two days. The entire attendance at all of the institutes during the year was 26,926. By comparing this with the attendance of the previous year (1,320) the progress of the institutes in Utah can be judged. Arrangements have been perfected for sending out an institute train next year which will cover every portion of the State in which railroad lines are found.

A field demonstration institute was held, at which about 500 persons were in attendance. There were also 13 women's institutes composed of 74 sessions. The method of conducting the institutes has been to hold men's and women's sessions separately during the day and conjointly at night. In order that a farmers' school may be held each county must guarantee at least 50 students and a fund of $50 to secure a five-day institute. Ten thousand copies of an annual report of the institute work were printed and distributed.

VERMONT.

Institute director.—F. L. Davis, secretary State board of agriculture, Woodstock.

The farmers' institutes in Vermont are held under the auspices of the board of agriculture. During the past season 28 institutes were held, consisting of two sessions each, with a total attendance of 5,160. The expense of the institutes for the year was $2,584.05. Special attention was given in the meetings to the development of the dairy cow and to the subjects of good roads, forestry, fruit growing, and truck farming. Four thousand copies of a report of the proceedings of the institutes were published and distributed. The director of institutes has called the attention of the board of agriculture to the importance of holding the meetings in the smaller villages and towns remote from the regular lines of railroad travel, and arrangements are being made to hold meetings in these outlying districts during the coming year.

VIRGINIA.

Institute director.—G. W. Koiner, commissioner of agriculture, Richmond.

By the provisions of an act of the Virginia legislature which took effect July 1, 1908, the farmers' institutes are under the control of the commissioner of agriculture in cooperation with a member of the board of agriculture in each Congressional district. Under the old law the institutes were wholly under the direction of the members of

the board of agriculture representing the ten Congressional districts and an appropriation of $500 for each district was available for meeting the expenses. There was no central supervision of the institute work of the State and comparatively few institutes were held, and no data respecting the number or attendance have been received.

The State farmers' institute organized four years ago at Roanoke, Va., held its annual meeting in 1907 at Roanoke, continuing through eight sessions, with a total attendance of 600. This organization is independent in character, and its expenses, which amounted to $739, were met by private subscription. The commissioner of agriculture, who now has the institutes in charge, has arranged for carrying this work during the coming year into all sections of the State.

WASHINGTON.

Institute directors.—R. W. Thatcher, acting superintendent farmers' institutes, Pullman; O. M. Olson, deputy superintendent farmers' institutes, Pullman.

After an interval of two years, in which no State aid for farmers' institutes was available, the legislature of 1907 made an appropriation of $10,000 for institutes for the biennium beginning April 1, 1907.

Seventy-eight institutes were held in Washington in 1907–8, composed of 240 sessions with a total attendance of 15,346, at a cost of $5,000, all of which was appropriated by the State. Twelve lecturers from the agricultural experiment station staff were upon the institute force and contributed one hundred and ninety-eight days of time. There were conducted in addition to the regular institutes three traveling dairy schools continuing through five days each; 1 five-day normal institute; 15 picnics; 5 grange specials; 8 street fairs; and 4 farmers' educational trains. The management intend to introduce into the institute work next year the teaching of domestic science.

An important feature of the work this year was the farmers' demonstration trains, three of which were operated over the lines of the steam railways in eastern Washington, and one on the Spokane and Inland Electric Railway. These trains were provided with cars containing exhibits, with day coaches in which the lectures might be held in case of inclement weather, and with private cars for the speakers and the railway officials who were in attendance. The stops rarely exceeded two hours at a place, and the work was necessarily inspirational rather than instructional. The trains aroused great interest in the work of the experiment station and the State college. A traveling dairy school with five-day stops was operated for one month in the dairy section adjoining Puget Sound in western Washington, and was well attended. The total attendance upon these trains was 11,910, and at the traveling dairy school 1,264.

WEST VIRGINIA.

Institute director.—J. B. Garvin, secretary State board of agriculture, Charleston.

During the past year the institute work in West Virginia has been placed directly in charge of the secretary of the board of agriculture. During the year 112 institutes were held, consisting of 365 sessions with an attendance of 16,748, at a cost of $5,644.41. Field meetings for demonstration work were held in six counties, with a total attendance of 3,000, and were reported to have been very satisfactory. In May, 1908, a department of field work was established and a superintendent was appointed. The work of the department of field work has been outlined as follows:

(1) To conduct movable schools of agriculture lasting for one week. These are to consist of classes in corn judging, live-stock judging, lectures upon the breeding of live stock and animal nutrition, fruit growing, dairying, and poultry raising.

(2) To promote agricultural education by means of educational trains.

(3) Visiting State normal schools and teachers' institutes and delivering lectures upon agricultural subjects.

WISCONSIN.

Institute director.—G. B. McKerrow, director farmers' institutes, Madison.

Institutes were held in Wisconsin in all of the counties excepting one. The total number was 141, made up of 47 one-day, 93 two-day, and 1 three-day institutes, and consisting of 567 half-day sessions. The total attendance was 89,244, and the total cost of the institutes was $12,000, not including the publication of 60,000 farmers' annuals (a 320-page book), which was about $5,500. There were in addition 25 cooking schools, made up of 51 sessions. A special-topic institute was held, and a number of special dairy institutes—an enlargement of the regular institute as it has been held in the dairy districts during the past fifteen years. Road building was discussed at all of the meetings, in order that the country people might vote intelligently upon an amendment to the constitution which proposes to permit the State to use public funds in internal improvements.

WYOMING.

Institute director.—J. D. Towar, director agricultural experiment station, Laramie.

Eleven institutes were held in Wyoming during the past year, composed of 46 sessions, and attended by 3,359 persons. The cost of the institutes, in addition to the local expenses made by the counties, was $767.61. Nine members of the agricultural college faculty and seven from the experiment station staff were employed upon the lecture

force and contributed eighty-seven days of time. There are a great many new settlers coming into the State, and the demand for farmers' institutes is growing. There are, however, several counties given over entirely to the live-stock work on immense ranches where farmers' institute work is not looked upon with favor. The large ranchman does not welcome the small farmer in his midst. Where meetings were held the past year there was every evidence of interest and a desire to have the institutes continued. A movement is on foot to conduct an institute train, and it is hoped that this may be perfected early in the spring.

STATISTICS OF FARMERS' INSTITUTES, 1908.

Number of institutes held and the approximate attendance during the year ended June 30, 1908.

State or Territory.	Number of one-day institutes.	Number of two-day institutes.	Number of three or more day institutes.	Total.	Total number of sessions.	Total attendance at all sessions.	Average per session.
Alabama	40			40	63	8,844	190
Alaska [a]							
Arizona	56			56	56	2,673	47
Arkansas	50	4	2	56	64	5,596	87
California	49	37	2	88	294	27,912	96
Colorado	118	7	1	126	240	38,930	162
Connecticut	24	1		25	53	3,700	86
Delaware	14	5		19	52	4,905	75
Florida	23	3		26	39	3,316	85
Georgia	38	2		40	84	12,000	142
Hawaii	4			4	4	150	37
Idaho	2	7	3	12	66	5,650	85
Illinois		62	46	108	627	122,523	195
Indiana	161	156	4	321	1,112	195,912	176
Iowa		75		75	400	75,000	187
Kansas	111	65		176	473	33,684	71
Kentucky	4	128		132	514	21,690	42
Louisiana [a]							
Maine	50			50	97	14,143	145
Maryland	21	20		41	117	8,903	76
Massachusetts	127			127	156	18,412	118
Michigan	248	76	2	326	969	121,654	126
Minnesota	267	5		272	547	92,091	167
Mississippi	124	3	2	129	274	28,910	104
Missouri	150	100		250	875	40,000	46
Montana	66	5	1	72	156	12,293	78
Nebraska	61	109	5	175	602	93,824	156
Nevada [a]							
New Hampshire	16			16	32	2,500	78
New Jersey	30	7		37	120	10,154	85
New Mexico	47	3	50	50	68	3,685	54
New York	142	161	4	307	1,471	149,418	102
North Carolina	194			194	423	52,978	125
North Dakota	81	8	1	90	233	38,000	163
Ohio		298		298	1,490	461,515	310
Oklahoma [a]							
Oregon	30	2		32	79	7,500	95
Pennsylvania	36	179	2	217	989	145,353	147
Porto Rico [a]							
Rhode Island	15			15	16	1,800	112
South Carolina	39	1		40	41	13,392	326
South Dakota	29	55	2	86	290	43,560	150
Tennessee	81		3	84	186	18,915	102
Texas	36			36			
Utah	4	10	11	25	288	26,926	94
Vermont	28			28	56	5,160	92
Virginia [b]							
Washington	57	17	4	78	240	15,346	64
West Virginia	12	100		112	365	16,748	46
Wisconsin	47	93	1	141	567	89,244	157
Wyoming	5	4	2	11	46	3,359	75
Total	2,737	1,808	98	4,643	14,934	2,098,268	140

[a] No institutes held. [b] No report.

Financial statistics of the farmers' institutes for the year ended June 30, 1908.

State or Territory.	Funds appropriated.		Cost.		Appropriation for the season of 1909.
	State.	College and other funds.	Total cost.	Cost per session.	
Alabama	$600.00	$400.00	$1,000.00	$15.87	$1,000.00
Alaska [a]					
Arizona	1,745.00		1,745.00	31.16	([b])
Arkansas	1,500.00		1,199.40	18.74	1,500.00
California	6,000.00	2,000.00	8,000.00	26.87	6,000.00
Colorado	5,560.46	2,164.00	7,724.46	32.19	5,000.00
Connecticut	1,700.00		825.00	28.78	1,500.00
Delaware	600.00	125.00	725.00	13.94	600.00
Florida	2,500.00		2,400.00	61.53	3,000.00
Georgia	2,500.00	1,500.00	4,000.00	47.61	4,000.00
Hawaii		74.49	72.60	18.15	([b])
Idaho	1,000.00		773.90	11.72	1,000.00
Illinois	24,000.00	5,540.00	30.097.99	48.00	7,650.00
Indiana	10,000.00	8,000.00	17,000.00	15.28	10,000.00
Iowa	5,350.75	2,604.23	7,954.98	19.88	6,000.00
Kansas	4,500.00	1,995.51	6,495.51	13.73	6,000.00
Kentucky	8,982.85		8,982.85	17.48	13,000.00
Louisiana [a]	2,000.00				2,000.00
Maine	3,000.00		[c] 3,000.00	30.93	3,000.00
Maryland	6,000.00		6,000.00	51.28	6,000.00
Massachusetts	4,000.00		[c] 1,608.95	10.31	4,000.00
Michigan	8,500.00		8,443.51	8.71	([b])
Minnesota	18,000.00	2,454.50	20,454.50	37.32	18,000.00
Mississippi	3,000.00	2,000.00	5,000.00	18.06	5,000.00
Missouri	5,000.00		5,000.00	5.71	([b])
Montana	7,500.00		7,500.00	48.07	7,500.00
Nebraska	10,000.00	3,617.68	10,760.47	17.87	10,000.00
Nevada [a]					
New Hampshire	1,000.00		[c] 900.00	28.13	([b])
New Jersey	2,500.00		2,500.00	20.83	8,000.00
New Mexico		1,425.00	1,425.00	20.95	800.00
New York	25,000.00		23,400.00	15.90	25,000.00
North Carolina	7,500.00		7,500.00	17.72	([b])
North Dakota	6,000.00	721.65	6,721.65	28.85	6,000.00
Ohio	22,000.00	1,986.15	19,882.77	13.34	22,000.00
Oklahoma [a]	1,285.29		695.58		3,000.00
Oregon	2,500.00		2,100.00	26.58	2,500.00
Pennsylvania	23,000.00		23,000.00	23.25	23,000.00
Porto Rico [a]					
Rhode Island	125.00		[c] 125.00	7.81	([b])
South Carolina	2,000.00		1,183.71	28.87	750.00
South Dakota	7,000.00		6,995.42	24.12	7,000.00
Tennessee	5,000.00		4,300.00	23.12	5,000.00
Texas	382.25		[c] 382.25	([b])	([b])
Utah	1,500.00	1,985.32	3,485.32	12.10	2,500.00
Vermont	5,000.00		2,584.05	46.13	([b])
Virginia [b]					
Washington	5,000.00		5,000.00	20.83	5,000.00
West Virginia	5,644.41		5,644.41	15.43	([b])
Wisconsin	20,000.00		12,000.00	21.16	20,000.00
Wyoming	1,000.00		[c] 767.61	16.68	1,000.00
Total	286,976.01	38,593.53	297,356.89	19.91	253,300.00

[a] No institutes held. [b] No report. [c] Not including the salary of the director.

Comparative statement of farmers' institutes.

	Appropriations.			Number of sessions.		Number of institutes.			Attendance.		
	1905–6	1906–7	1907–8	1906–7	1907–8	1905–6	1906–7	1907–8	1905–6	1906–7	1907–8
Alabama	$600.00	$600.00	$1,000.00	33	63	35	24	40	8,590	2,857	8,844
Alaska [a]	......	......	......	......	......	......	......	......	......	......	......
Arizona	608.85	300.00	1,745.00	20	56	21	20	56	1,307	1,000	2,673
Arkansas	400.00	......	1,500.00	41	64	31	40	56	7,150	3,000	5,596
California	9,000.00	6,000.00	8,000.00	296	294	83	84	88	22,861	20,470	27,912
Colorado	4,000.00	5,003.19	7,724.46	171	240	40	62	126	16,675	16,960	38,930
Connecticut	1,825.00	2,435.57	1,700.00	74	53	24	38	25	4,895	9,522	3,700
Delaware	725.00	700.00	725.00	51	52	18	12	19	7,200	9,210	4,905
Florida	......	7.00	2,500.00	1	39	......	1	26	......	30	3,316
Georgia	2,500.00	2,500.00	4,000.00	(b)	84	21	(b)	40	4,500	(b)	12,000
Hawaii	33.45	62.05	74.49	6	4	4	3	4	300	500	150
Idaho	1,000.00	142.08	1,000.00	14	66	21	1	12	7,875	550	5,650
Illinois	30,281.55	28,978.96	29,540.00	589	627	108	111	108	79,428	333,350	122,523
Indiana	12,500.00	12,700.00	18,000.00	996	1,112	250	281	321	129,894	177,441	195,912
Iowa	8,096.06	7,425.00	7,954.98	340	400	69	85	75	66,959	51,000	75,000
Kansas	2,000.00	4,064.00	6,495.51	358	473	155	135	176	27,300	20,200	33,684
Kentucky	1,750.00	13,000.00	8,982.85	335	514	25	123	132	......	26,836	21,690
Louisiana	2,000.00	2,000.00	2,000.00	10	......	22	10	......	2,657	(b)	(a)
Maine	5,000.00	5,000.00	3,000.00	65	97	50	33	50	6,967	4,771	14,143
Maryland	6,000.00	6,000.00	6,000.00	121	117	49	23	41	......	9,833	8,903
Massach'tts	3,000.00	2,750.00	4,000.00	155	156	125	126	127	19,125	19,692	18,412
Michigan	15,000.00	15,500.00	8,500.00	965	969	335	329	326	122,573	115,136	121,654
Minnesota	20,238.40	20,665.00	20,454.50	282	547	105	139	272	51,211	67,063	92,091
Mississippi	3,000.00	3,000.00	5,000.00	296	274	110	148	129	10,000	17,945	28,910
Missouri	5,000.00	5,000.00	5,000.00	372	875	156	212	250	36,900	46,511	40,000
Montana	5,000.00	5,000.00	7,500.00	78	156	71	70	72	7,890	7,541	12,293
Nebraska	8,607.00	8,684.04	13,617.68	442	602	160	136	175	72,894	65,419	93,824
Nevada [a]	......	......	......	......	......	......	......	......	......	......	......
N. Hampsh'e	2,100.00	1,600.00	1,000.00	34	32	16	15	16	3,000	3,500	2,500
New Jersey	3,000.00	3,060.98	2,500.00	132	120	40	44	37	11,611	10,399	10,154
New Mexico	(a)	1,900.00	1,425.00	29	68	(a)	24	50	(a)	970	3,685
New York	20,000.00	20,000.00	25,000.00	834	1,471	259	211	307	134,989	105,196	149,418
N. Carolina	5,500.00	6,500.00	7,500.00	246	423	96	124	194	25,950	31,980	52,978
N. Dakota	6,379.07	6,000.00	6,721.65	99	233	43	25	90	20,310	9,709	38,000
Ohio	17,629.89	22,000.00	23,986.15	1,495	1,490	245	299	298	81,816	92,303	461,515
Oklahoma	660.00	550.00	1,285.29	99	......	31	40	......	7,460	6,715	(a)
Oregon	2,500.00	3,000.00	2,500.00	148	79	44	58	32	16,350	22,200	7,500
Pennsylv'a	20,500.00	20,500.00	23,000.00	981	989	226	394	217	165,553	147,895	145,353
Porto Rico	(a)	(a)	(a)	(b)	......	1	(a)	......	50	(a)	(a)
Rhode Isl'd	100.00	75.00	125.00	9	16	1	7	15	300	600	1,800
S. Carolina	4,524.40	3,000.00	2,000.00	93	41	54	73	40	11,149	13,219	13,392
S. Dakota	6,500.00	5,000.00	7,000.00	280	290	59	71	86	10,000	26,000	43,560
Tennessee	2,500.00	5,000.00	5,000.00	51	186	35	48	84	6,000	10,400	18,915
Texas	540.00	(a)	382.25	(a)	......	27	(a)	36	4,500	(a)	(b)
Utah	2,000.00	(b)	3,485.32	(b)	288	45	(b)	25	6,680	(b)	26,926
Vermont	5,000.00	5,000.00	5,000.00	68	56	38	34	28	7,962	7,288	5,160
Virginia	5,000.00	[c]2,500.00	(b)	[c]16	(b)	......	[c]7	(b)	19,500	[c]310	(b)
Washington	(a)	(a)	5,000.00	70	240	......	24	78	(a)	5,250	15,346
W. Virginia	3,966.12	7,476.71	5,644.41	373	365	81	110	112	4,480	24,825	16,748
Wisconsin	12,000.00	12,771.09	20,000.00	311	567	81	61	141	32,200	49,989	89,244
Wyoming	1,107.59	1,000.00	1,000.00	35	46	11	12	11	3,401	1,292	3,359
Total	269,672.38	284,450.67	325,569.54	11,514	14,934	3,521	3,927	4,643	1,299,172	1,596,877	2,098,268

[a] No institutes held. [b] No report. [c] Report for 2 districts only.

Number of lecturers employed by the state directors of farmers' institutes during the year ended June 30, 1908.

State or Territory.	Total number of lecturers on the state force.	Number of members of agricultural college and experiment station staffs engaged in experiment work.	Number of days contributed to institute work by the agricultural college and experiment station staff.	Total number of days of institutes held during the year.	Reports of proceedings.	
					Published.	Number of copies.
Alabama	14	7	210	40	No	
Alaska[a]						
Arizona	3	3	25	56	No	
Arkansas	6	12	112	64	No	
California	36	10	100	129	Yes	12,500
Colorado	21	37		135	No	
Connecticut	54	7	35	26		
Delaware	9	5	40	24	Yes	5,000
Florida	14	2		29	No	
Georgia	14	10	110	42	No	
Hawaii				4	No	
Idaho	10	13	20	22	No	
Illinois	91	30	260	262	Yes	20,000
Indiana	49	9	62	485	Yes	1,000
Iowa	16	5		150	No	
Kansas	34	11	190	241	No	
Kentucky	22	10		260	Yes	25,000
Louisiana[a]	11					
Maine	25	2		50	Yes	6,000
Maryland	9		90	61	No	
Massachusetts	58		9	127	Yes	(b)
Michigan	47	15	46	406	Yes	10,000
Minnesota	16	3	36	277	Yes	35,000
Mississippi	23	14	140	136	Yes	10,000
Missouri	23	14	120	350	No	
Montana	22	13	199	79	Yes	6,000
Nebraska	44	13	47	294	Yes	2,000
Nevada[a]	7					
New Hampshire	16	16		16	Yes	1,500
New Jersey	12	5	20	44	Yes	6,000
New Mexico	11	6	157	53	No	
New York	61	20		476	Yes	5,000
North Carolina	33	10	45	194	Yes	30,000
North Dakota	7	1	90	100	Yes	10,000
Ohio	51			596	Yes	20,000
Oklahoma[a]	6					
Oregon	16	6	111	34	No	
Pennsylvania	73	10	176	400	Yes	8,000
Porto Rico[a]	6					
Rhode Island	16	7	17	15	Yes	2,500
South Carolina	10	12	40	41	No	
South Dakota	8	2	265	145	No	
Tennessee	17	2	84	87	Yes	1,350
Texas		5	21	36	No	
Utah	18	24	427	57	Yes	10,000
Vermont	13	8	182	28	Yes	4,000
Virginia[b]	8					
Washington	18	12	198	103	Yes	1,000
West Virginia	27	4	65	212	No	
Wisconsin	24	15	15	123	Yes	60,000
Wyoming	13	16	87	19	Yes	6,000
Total	1,142	426	3,851	6,528		297,850

[a] No institutes held.

[b] No report.

Appropriations, number of sessions, attendance at institutes in the United States for the year ended June 30, 1908, the approximate population in farm homes in 1900, and the percentage of attendance to the population in farm homes.

State or Territory.	Amount appropriated.	One-half day sessions.	Attendance.	Population in farm homes in 1900 (approximate).[a]	Percentage of attendance to population in farm homes.
Alabama	$1,000.00	73	8,844	1,060,644	0.83
Alaska[b]				127	
Arizona	1,745.00	56	2,673	30,362	8.80
Arkansas	1,500.00	64	5,596	870,878	.64
California	8,000.00	294	27,912	308,891	9.04
Colorado	7,724.46	240	38,930	104,701	37.18
Connecticut	1,700.00	53	3,700	119,003	3.11
Delaware	725.00	52	4,905	45,260	10.84
Florida	2,500.00	39	3,316	184,989	1.79
Georgia	4,000.00	84	12,000	1,077,138	1.11
Hawaii	74.49	4	150	5,852	2.56
Idaho	1,000.00	66	5,650	74,091	7.63
Illinois	29,540.00	627	122,523	1,219,852	10.04
Indiana	18,000.00	1,112	195,912	973,870	20.12
Iowa	7,954.98	400	75,000	1,037,811	7.23
Kansas	6,495.51	473	33,684	763,186	4.41
Kentucky	8,982.85	514	21,690	1,153,032	1.88
Louisiana	2,000.00			554,031	
Maine	3,000.00	97	14,143	243,063	5.81
Maryland	6,000.00	117	8,903	230,480	3.86
Massachusetts	4,000.00	156	18,412	165,515	11.12
Michigan	8,500.00	969	121,654	893,342	13.62
Minnesota	20,454.50	547	92,091	779,470	11.81
Mississippi	5,000.00	274	28,910	1,075,030	2.78
Missouri	5,000.00	875	40,000	1,340,079	2.98
Montana	7,500.00	156	12,293	60,588	20.29
Nebraska	13,617.68	602	93,824	564,072	16.63
Nevada[c]				8,170	
New Hampshire	1,000.00	32	2,500	118,948	2.10
New Jersey	2,500.00	120	10,154	160,111	6.34
New Mexico	1,425.00	68	3,685	55,272	6.67
New York	25,000.00	1,471	149,418	1,010,376	14.79
North Carolina	7,500.00	423	52,978	1,145,755	4.62
North Dakota	6,721.65	233	38,000	217,657	17.46
Ohio	23,986.15	1,490	461,515	1,237,790	37.20
Oklahoma	1,285.29			476,767	
Oregon	2,500.00	79	7,500	163,761	4.52
Pennsylvania	23,000.00	989	145,353	1,077,660	13.49
Porto Rico[b]					
Rhode Island	125.00	16	1,800	25,713	7.00
South Carolina	2,000.00	41	13,392	759,959	1.76
South Dakota	7,000.00	290	43,560	249,776	17.43
Tennessee	5,000.00	186	18,915	1,135,585	1.67
Texas	382.25			1,768,251	
Utah	3,485.32	288	26,926	96,308	27.96
Vermont	5,000.00	56	5,160	138,830	3.72
Virginia[c]				867,758	
Washington	5,000.00	240	15,346	155,430	9.87
West Virginia	5,644.41	365	16,748	487,070	3.44
Wisconsin	20,000.00	567	89,244	823,478	10.84
Wyoming	1,000.00	46	3,359	27,296	12.31
Total	325,569.54	14,934	2,098,268	26,143,078	9.33

[a] This approximation is arrived at by estimating that the number of persons in a farm home is equal to that in other homes, and that the percentage of farm homes is, therefore, also the percentage of rural population.

This estimate is not strictly accurate, for the census enumerators in taking account of farm homes did not include a home, although situated in the country, which "consists of only a dwelling and ground upon which it stands, with appurtenances thereto, but is not occupied by what may be termed a farm family." (Census Report of 1900, pt. 2, Population, p. clxxxvii.) Neither are there included farm laborers who reside in towns and cities, but who work out on farms. The figures, therefore, given for farm population are below rather than above the actual number engaged in agriculture.

[b] No institutes held.

[c] No institutes reported.

ANIMAL NUTRITION PROBLEMS IN RELATION TO THE WORK OF THE EXPERIMENT STATIONS.

By C. F. Langworthy, *In Charge of Nutrition Investigations.*

In a consideration of physiological chemistry in relation to animal nutrition it seems desirable to note something of the growth of the subject, the problems which have been studied, and the methods which have been followed in the immediate past; to endeavor to set forth the point of view at the present time, citing some of the noteworthy investigations which are being made, particularly by workers in the American experiment stations; and to endeavor to point out lines of work which promise results of theoretical or practical importance. The fact should never be lost sight of that the General Government has given to each State an annual sum, which, if it represented the income from an endowment given by some wealthy citizen, would be justly regarded as a marvel of generosity, but which scarcely causes comment, coming as it does without any heralding. This fund is designed to foster the study of agricultural research in the broadest sense of the term, or perhaps better, research in science as related to agriculture, for it is true that agriculture is not a science apart, but rather that the fundamental sciences—physics, chemistry, biology, etc.—can be applied to the study of agricultural problems.

It is the purpose of the Hatch fund to encourage investigation, and the Adams fund is even more specific in its requirements that research work shall be carried on. The experiment-station workers, therefore, are not only provided with laboratory facilities and funds, but are specifically instructed by Congress to devote their attention to the solving by experimental methods of problems related to agricultural science. The contribution which has been made in the past to all lines, and particularly those pertaining to the nutrition of farm animals, is very considerable, and the expectation is certainly justified that the increased resources of the stations under the Adams Act will mark a great step forward in their scientific activity.

The centuries of association of man with domestic animals kept for his pleasure or material profit has naturally resulted in a very large fund of empirical knowledge regarding their care and management, and no one would deny that knowledge thus gained is of the utmost importance. Such knowledge, however, though it may yield results, seldom gives much clew as to how or why the results are obtained nor

does it explain the failures which are not infrequent when empirical knowledge is the only guide.

The last century has witnessed a marvelous growth in scientific methods of study and in the spread of investigation. Physics, chemistry, and the other branches of science as the term is ordinarily understood, perhaps naturally were made the subject of careful study long before it was realized that the homely problems of everyday life, such as the management of the household and the feeding and care of live stock, were also capable of investigation by laboratory methods and would repay careful study equally well.

It is the hope of so placing animal production as an industry that it may be comparable with other enterprises, and of so definitely controlling conditions and thoroughly understanding causes that failure may be eliminated, which has led to the study of its problems by the methods which have proved valuable in other branches of science.

The growth of physiological chemistry, particularly as applied to animal nutrition, has been comparatively rapid.

Perhaps it was the study of problems of physiology and pathology and of the treatment of disease by physiologists and physicians which led most naturally to the study of questions of animal chemistry, and this is naturally the case since the fundamental laws of growth, whether we consider the term restricted to changes in the cell or to the much more obvious changes in the body as a whole, are the same for all forms of animal life. The selection of the animal for study for experimental purposes is very largely a matter of convenience. Experiment-station investigators have very generally and very naturally selected farm animals for experimental purposes, though occasionally other animals have been used. Investigators in university laboratories and kindred institutions have more commonly worked with small animals which could be more conveniently managed, and it is probably the selection of such animals for experimental purposes which has prevented a more general application of such results to practical problems of animal feeding for economic purposes, for it is undoubtedly true that physiological literature contains a large amount of information regarding both methods and results which could be profitably interpreted in relation to economic problems.

For the last thirty or forty years physiological chemistry, considering the subject particularly in its relation to animal production, has been chiefly concerned with the proximate analysis of feeding stuffs, with feeding experiments in which different materials and combinations were compared with reference to their effect on growth, milk yield, egg production, the use of animals as beasts of burden, and similar problems. Such studies have also included the effects of different systems of housing and care and management. Digestion experiments have likewise been fairly common, and studies of the

metabolism of nitrogen have not been infrequent. A great many questions which have to do with the composition of milk and other animal products, the changes which occur in cheese making and other dairy processes, and similar subjects have often been investigated, and when we consider a definite period like that which has elapsed since the establishment of the experiment stations in the United States, it can be seen that each decade has marked a forward movement, some investigator or group of investigators having pushed forward beyond the general line of advance.

Exact measurements and attempts at formulating standards for comparison were naturally the first steps from empirical to experimental knowledge in animal feeding. The earlier attempts at measuring feeding values were not satisfactory. Doubtless all will recall the system in which "hay values" were proposed and feeding stuffs were compared with hay as a standard, the data for such comparisons being gathered by noting the quantities of different feed which animals would eat in comparison with hay.

As chemical methods improved and analytical studies became general, feeding stuffs, as well as a multitude of other materials, were studied, but elementary analyses did not give results of much value, since it is difficult to interpret data regarding the proportions of carbon, nitrogen, and hydrogen and oxygen in a material in such a way that its comparative food value can be known. It was felt that with such materials it was a question of the compounds which were present, rather than of elementary composition, and a great step forward was taken when about fifty years ago the theories of proximate composition were advanced and the methods of proximate analysis were devised by Henneberg[a] at the Weende Experiment Station in Germany, which, with numerous improvements, have been followed up to the present time. Useful as this method of studying feeding values has been in the past, indications are not wanting that both the method and the theories which are based upon it have in large measure served their purpose, and that some system of comparison which gives more definite results is needed.

If one stops to consider studies of the proximate composition of feeding stuffs, it becomes evident that, except in the case of new materials or materials examined for some special purpose, there seems little need for further work along these lines; first, because the information already at hand is so extended that it will serve all ordinary purposes, and, secondly, because many of the problems which are being studied concerning growth and development with reference to food supply require a more detailed knowledge of food composition for their interpretation. There is, however, one branch of the subject in which proximate analyses are needed, and that is the ques-

[a] Land. Vers. Stat., 6 (1864), p. 496.

tion of composition in relation to the guaranties which are required in most States under the laws which have been enacted regarding composition of feeding stuffs. This question has come to be of great importance to experiment station workers, owing to the fact that the work of inspection has been very generally assigned to the stations.

Realizing that the older methods of proximate analysis do not give sufficient data regarding the character of a feed, a number of the stations have sought to determine the kind and amount of constituents making up the principal proximate groups. As an illustration may be cited the recently published work of the New Jersey Station,[a] in which the different members of the carbohydrate group were determined in great detail in analyses of beet pulp.

It has been known for a long time that fats which occur in animal and vegetable products are alcoholic salts of fatty acids. The fact that the ordinary sugars and starches are intermolecular anhydrids of hexatomic alcohols is a knowledge which was acquired considerably later, and, indeed, it is only a few years since E. Fischer[b] and his coworkers cleared up the mystery of the carbohydrate group and showed the true molecule nature of the sugars, starches, the pentosans, and other similar bodies with either six or more or less than six carbon elements; devised methods for the synthesis of such compounds, and, in a word, made plain the chemical nature of this important group of chemical compounds.

Until very recently our knowledge of the true nature of the nitrogenous compounds, which have been grouped under the heading "protein," has been very vague, but this is no longer the case, and thanks to the labors of Fischer[c] and other chemists we can now say, apparently with certainty, something concerning the true chemical nature of the proteids and other nitrogenous bodies which occur in plant and animal tissues.

The structure of a watch or any other delicate piece of mechanism may be understood by taking it apart and examining the various pieces which make up the whole. In the same way the chemist frequently gains his knowledge of a complex compound by breaking it down and studying the cleavage products. Information regarding the structure of the protein has been very largely gained in this way, and it has been found that the units which make up the molecule are amino acids and that the number present varies very greatly, some proteids having only 3 or 4 and others 10, 20, or an unknown number.

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[a] New Jersey Sta. Rpt. 1906, p. 39.

[b] E. Fischer, Untersuchungen über Kohlenhydrate und Fermente (1884–1908). Tollens' Kurzem Handbuch der Kohlenhydrate. Breslau, 1888.

[c] Untersuchungen über Aminosäuren Polypeptide und Proteïne (1899–1906). Chem. News, 96 (1907), pp. 207–212.

One of the largest contributions to this field of knowledge has been made at the Connecticut State Station by Osborne[a] and his associates.

When it is recalled that different proteids vary greatly as to the kind and number of amino acids which make up the bulk of the molecule, it is easy to understand that the proteids may have different functions in nutrition and that the time is not far distant when our feeding standards will be expressed, not in terms of protein—that is, nitrogen multiplied by the factor 6.25—but will call for specific proteids. For instance, wheat may be fed instead of corn under certain conditions, because of the 30 per cent glutaminic acid found in its cleavage products as compared with 17 per cent contained in Indian corn.

The usual, or at least the earlier, method of expressing feeding standards was in terms of protein, fat, and carbohydrates, together with the fuel value, the ash being generally left out of account, and very often the results have been expressed in terms of digestible nutrients. There has been for some time a tendency in discussions of human nutrition to use only protein and energy for a similar purpose, since on theoretical grounds it is immaterial, within limits, whether the energy of a ration aside from that of protein is supplied by fat or by carbohydrates. The nutritive value of a ration or the nutritive value of a feeding stuff is also often expressed simply by stating its protein and energy content, since these values represent the uses which food serves in the body.

This question of the proper expression of nutritive value of materials and rations has received a good deal of attention in recent years in connection with animal nutrition. Some of the German investigators have proposed to use for the energy value the total energy less the energy of excretory products, and have called this quantity "physiological nutritive value."

Zuntz[b] has advocated a plan in which so-called starch values are used in place of energy values, i. e., a quantity of starch which would be equivalent in energy value to the total energy under consideration.

The question of the proper expression of nutritive values has formed an important part of the investigations conducted by Armsby[c] at the Pennsylvania Station, in which he has had the great advantage of measuring with the respiration calorimeter the energy quantities which most other investigators have been compelled to calculate. As a result of his work, he has proposed the use of the term "metabolizable energy," by which is meant the total

[a] Conn. State Sta. Bul. 105 and later publications. Amer. Jour. Physiol., 20 (1905), p. 494. Carnegie Inst. Washington Pub. 84, and many other papers.

[b] Principles of Animal Nutrition. New York, 1903.

[c] U. S. Dept. Agr., Bur. Anim. Indus. Bul. 74.

energy of the ration or material under consideration less the energy of excretory products produced when it is eaten and also less the energy expenditure necessary for the assimilation of the material.

It appears that the purpose for which a feeding stuff is used is a very important factor in discussing its nutritive value—that is, materials have a different value when used for maintenance than they do when they serve for the production of muscular work. This is a question which has been studied by Kellner, and as a result of his work he has provided tables of productive values for the more important feeding stuffs, which are apparently reasonably accurate expressions of actual facts. The subject is being studied by Armsby and his associates at the Pennsylvania Experiment Station, and this question and others which have to do with the expression of nutritive value of feeding stuffs are discussed at considerable length in a paper which Armsby presented before the Baton Rouge convention of the Association of American Agricultural Colleges and Experiment Stations.[a]

To turn from analyses and feeding standards to feeding experiments, it appears that the total number which have been reported in the United States alone is very large, for this line of work has in many cases engaged the attention of experiment station workers to the exclusion of other questions. Such experiments have led to valuable conclusions, particularly with reference to farm practice.

The feeding standards which are so generally used, and which are guides for intelligent management, though not expressions of physiological requirements, a point which can not be too often emphasized, have been very largely deduced from feeding experiments and represent the averages of observations of the amounts actually consumed under different conditions and followed by different results. Feeding experiments have also shown that under many conditions it does not pay to grind feed, since the extra gain which this method of preparation may secure is not great enough to cover the cost of grinding if any particular expense is incurred. In the same way it appears that cooking feed is not usually profitable. It is also to experiments of this type that we are indebted for fairly exact knowledge regarding the amount of different feeds which will be required for a pound of gain or for the production of a quart of milk.

These facts and others like them are of great value, and when properly used such data help the feeder to secure the returns from his labors which he has a right to expect; but every one recognizes that they do not cover the whole question, and that there are many details of handling and of care which can not be studied as a part of feeding, and that the almost instinctive knowledge of live stock and their ways, which many feeders possess, is at least of equal importance.

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[a] Experiment Station Record, 18 (1906-7), p. 508.

One of the important results which may perhaps in justice be said to rest upon feeding experiments has to do with the economic production of baby beef—the system of feeding which under some conditions is perhaps the most profitable which can be followed and which produces a quality of flesh for which there is an increasing market demand.

An instance of the inadequacy of feeding experiments in the solution of certain problems of animal nutrition may be found in the case of cotton-seed meal. As everyone knows, this material is poisonous to pigs if fed in quantity for any considerable time. The reason for this has been often sought by station investigators and others and has been often the special point considered in feeding experiments. The work has yielded some practical results. For instance, it has been shown that with an abundance of green feed reasonable quantities of cotton-seed meal may be fed to pigs for some time without unfavorable results, and it also appears that steaming the meal or fermenting it does not destroy the toxic properties. Examination of the carcasses has shown that there are certain degenerative changes, particularly in the renal tract, but the real cause of cotton-seed poisoning of pigs still awaits explanation.

Feeding experiments have also, it is only fair to say, made some contribution to an understanding of the laws of nutrition. For instance, they have shown that the material required for a pound of gain increases as the feeding period progresses, but they have not shown why this is the case any more than they have shown what constitutes the superior skill or intelligence in management which has been alluded to as the instinctive knowledge possessed by certain feeders.

As regards future work, feeding experiments, it would seem, may be most profitably resorted to in the study of materials which are not well known but which may possibly assume considerable importance. As an instance, molasses and sugar feeds may be cited. No longer than ten years ago the use of such materials in the feeding of farm animals was confined almost exclusively to a few regions and was practically unknown elsewhere. The rapid development of the beet-sugar industry, which involved the production of a large amount of molasses and of beet chips, beet pulp, etc., as by-products, has changed the situation, and a good deal of attention has been profitably spent in recent years in studying the feeding value of molasses and molasses mixtures and other sugarhouse by-products.

The question of the possible use and the real value of cactus as a feeding stuff is another problem which has received attention, and the recent work of the New Mexico Experiment Station[a] and of

[a] New Mexico Sta. Bul. 60.

other investigators,[a] which includes feeding experiments and tests of digestibility, has had decided value in settling the question of the relative importance of cactus feed prepared in different ways.

Some interest has been manifested by the agricultural press regarding the possible use of water hyacinth as a feeding stuff, a plant which is a pest, for instance, in Florida rivers, and which has hitherto seemed of no possible value. So far the studies of this plant have not been promising, but its possible use is a question which could be readily settled by means of feeding tests.

Another similar topic is the question of the value of sweet clover, fresh and cured. In many regions, particularly in the Northern States, this plant, which is rapidly spreading as a roadside weed and finds a high favor with bee keepers, is bitterly denounced by farmers as a whole as a valueless weed and a menace to farm crops. On the other hand, in some of the southern United States, where different conditions prevail, many feeders are enthusiastic in praise of sweet clover as a stock feed and as a rejuvenator of worn soils, particularly those of a calcareous nature. They claim that live stock learn to eat sweet clover readily and that it compares favorably with alfalfa, both fresh and cured, provided it is properly handled. Such a question is certainly worth study, and well-conducted feeding experiments should settle the true feeding and agricultural value of this plant.

In general it may be said that the number of problems like the above is not large compared with the total number of questions of a different nature which suggest themselves for investigation, and there is good reason for believing that the limit of usefulness of the ordinary feeding experiment is being reached.

Realizing that, except in a few cases, the making of ordinary feeding experiments is but thrashing over old straw, some of the experiment station investigators are turning their attention to the study of feeding problems by methods which are apparently much more promising. To cite an instance, at the Missouri Station a series of investigations on the fattening of beef catle has been instituted, in which careful records are kept not only of changes in body weight, but also of changes in external conformation, and in which the character of the lean and fat produced, its distribution, chemical nature, and other characteristics are considered, in so far as they can be measured. A primary object of this work is to study the rate of growth; that is, the increase in weight of the vital organs, the skeleton and the protein tissue, as distinguished from fat, during each period of the life of a steer from birth to maturity; to measure when the

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[a] California Sta. Rpt. 1904, p. 49; Arizona Sta. Rpt. 1904, p. 496; Arizona Sta. Bul. 51.

period of most rapid growth ends and to measure the effect of this growth upon the ability of the animal to fatten. The methods which have been elaborated, for instance, for the identification and study of the fat formed on different feeds, and which evolve the use of different sorts of staining reagents, are apparently capable of wide application.

As Professor Waters[a] has pointed out, the Missouri work is primarily a study of the life history of domestic animals in which the attempt is being made to ascertain what factors favor and what factors hinder growth and development. The influence of nutrition upon the size and form of the animal contrasted with heredity is being investigated, and the station is attempting in this research to separate the field and function of the breeder of animals from that of the man who subsequently feeds them.

Work on fat which involves a similar technique to that of the Missouri Station, and which is of great interest and value, has been carried on for some time with poultry at the Cornell Agricultural College and Station.[b]

Mention should also be made of the investigations which were instituted by Jordan and Hart[c] at the New York Geneva Station for studying the exact effects of certain grain constituents, particularly the phosphorous compound of wheat bran which is called phytin, and which has physiologically active properties, as well as being apparently a valuable source of the phosphorus which the body needs.

As has been said already, in ordinary feeding standards no mention is usually made of ash constituents, though a considerable amount of analytical data is available regarding the total ash and also the different ash constituents of a great variety of feeding stuffs. Careful study of the subject, however, shows that, particularly in the case of earlier work, the methods employed for determining ash constituents are oftentimes open to serious objections, and as is usually the case with all ash determinations made at the time, the reported values are not very trustworthy.

As regards ash, the assumption has been that the total amount of ash constituents required by an animal, at least after the earlier period of its life, is comparatively small and certainly less than the total amount of ash which would be supplied under usual conditions by any ordinary ration. A decided change is now noticeable in the attitude of investigators with respect to ash constituents and their importance, and many investigators are turning their attention to this

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[a] Personal communication.

[b] Science, n. ser., 28 (1908), p. 494.

[c] New York State Sta. Tech. Bul. 1.

phase of the subject, believing that the solution of many vexed questions will be found in this way.

For instance, it seems probable from the results of studies of human nutrition, and of course the fundamental laws of nutrition are the same for man and animals, that ash requirements and protein requirements are in some way interdependent, and that the physiological requirement for protein can not be definitely decided until this relationship is more thoroughly understood. It will be recalled that in pig feeding it has been very commonly observed that an exclusive corn ration does not produce good results, either as regards gains in weight or the character of the carcass, tender intestines and soft bones as well as other somewhat abnormal conditions being often noted as a result of such feeding. Corn is not very rich in protein as compared with many other feeds, and it was suggested that these unfavorable conditions were due to a lack of protein in the ration, a view which was strengthened by the fact that adding some food richer in protein than corn usually brought about decided improvement. Others have suggested that the unfavorable results attending a ration of Indian corn are ascribable to specific qualities in the zein, the principal maize proteid. Recently published Italian work adduces proofs of this contention, and it finds further support in the great differences observable in the amount and character of the cleavage products obtained from zein and from other proteids.

It has also been suggested that the small amount of mineral matter in Indian corn is responsible for the unfavorable conditions observed, and it is certainly true that adding ash constituents to the ration has a decidedly favorable effect.

Similarly, the Hawaii Experiment Station[a] has shown that the lack of thrift in Hawaiian cattle is ascribable to the deficiency of lime in many of the local grown feeding stuffs.

An interesting contribution to the question of mineral matter and its importance in the nutrition of the animal body has been made very recently by Harcourt and Fulmer[b] at the Ontario Agricultural College in connection with a series of chemical and physical studies of various incubation problems. These investigators determined the percentage of shell, white, and yolk in a large number of eggs and the phosphoric acid and calcium oxid content of these different parts of the egg. Studies made of the lime content of eggs during different periods of incubation showed that for eleven days there was practically the same amount of lime in the partially developed chick as in the contents of the original egg, but at the end of the incubation there was a very decided increase, apparently due to the withdrawal of lime from the eggshell. While definite conclusions are not drawn

[a] Hawaii Sta. Bul. 13.

[b] Ontario Dept. Agr. Bul. 163.

the authors still think it probable that there is some relation between the lime content of the chick and its vitality.

Such problems as these are well worth study, and no opportunity should be lost of directing the attention of station investigators to this kind of work, in the hope that it may become a permanent feature of station enterprises.

In the case of digestion experiments, which constitute one of the principal kinds of investigation in the study of animal nutrition, the methods which have been followed in the past have given satisfactory results, and this line of investigating can be profitably extended with a view to accumulating data regarding the comparative digestibility of many additional sorts of feeding materials, as well as with reference to the relative digestibility of similar feeds by different kinds of farm animals. Greater accuracy is desirable, however, in the separation of feces pertaining to the food or ration under consideration, as well as more adequate methods for distinguishing between the undigested residue and the metabolic products of feces.

Work of the sort referred to in which the coefficients of digestibility of the several nutrients of the feed or ration are determined by deducting the undigested material from the total amount consumed, useful as it is for purposes similar to those mentioned, does not throw any light upon the processes of digestion in the body itself, which, from a theoretical as well as from a practical standpoint, is a matter of the greatest interest, and it is not surprising to find that an increasingly large number of investigators are turning their attention to different phases of the question. For instance, the kind and amount of enzyms secreted in different portions of the digestive tract, the factors which stimulate and which hinder the flow of digestive juices, the character and extent of the muscular movements which force food through the digestive tract, the forms in which products of digestion are assimilated, the possibility of replacing food protein with simpler nitrogenous compounds, as amino acids like those formed from protein during the digestive processes, and a host of others are being studied in the United States and elsewhere. Experiments in human nutrition indicate that the microscope may be used with decided advantage in interpreting the results of digestion experiments.

Thoroughness of digestion of different feeding stuffs has also been commonly studied with the aid of so-called artificial digestion experiments, in which materials are treated with solutions of digestive ferments under conditions approximating more or less closely those of natural digestion. The methods most used were devised a number of years ago, though some important modifications have been recently

proposed. Many investigators believe that comparative ease of digestion may also be studied by such methods. This is a field of work which has as yet received little attention in the American stations, though a great number of problems suggest themselves as worthy of study.

Questions involving the mechanism of digestion, such as Scheunert's[a] studies of the selective functions of the stomach, are also worth the attention of station investigators. He concluded that this organ does not exercise such a selective function, all the materials leaving the stomach in the same way, the more rapid disappearance of the digestible material in some cases being due to the absorptive power of the stomach. Problems such as this would well repay careful study.

Very recently a marked interest is noticeable in questions which have to do with incubation of eggs. Mention has already been made of some of the studies of the chemical changes in the egg embryo and of the part played by the shell in the growth and development of the chick. An extended series of studies on natural and artificial incubation was reported by Eycleshymer,[b] the work being carried on at St. Louis University. Particularly noteworthy are the observations of the temperature of the eggs during incubation, which was found to range from 98 to 103° F., the proper incubating temperature of the egg, according to the results obtained, being 100° for the first week, 101° for the second, and 102 and 103° for the final week. In any consideration of temperature the fact must be borne in mind that as the chick grows it gives off more and more heat. In natural incubation this heat is carried away by the air which circulates through the hen's feathers, and in an incubator this extra heat must be taken into account in regulating the temperature, and it consequently follows that less artificial heat is needed during the latter stages of incubation than earlier in the process.

In connection with this work it is interesting to note some experiments by Tangl and Mituch,[c] published a little later, which led to the conclusion that on an average 61 calories, or two-thirds of the total energy value of the egg, were required in the incubation processes, of which 38 calories were represented by the material making up the chick's body at the time of hatching, while the remaining 23 calories were used in the development of the chick and measurable as heat. In other words, these investigators have measured the quantity of heat to which Eycleshymer referred. They furthermore conclude that the energy required for the development of the chick is largely

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[a] Arch. Physiol. [Pflüger], 114 (1906), p. 64; Ztschr. Physiol. Chem., 51, (1907), p. 519.

[b] Biol. Bul. Mar. Biol. Lab. Woods Hole, 12 (1907), p. 360.

[c] Arch. Physiol. [Pflüger], 121 (1908), p. 437.

supplied by the egg fat, as this constituent is the one which is mainly broken down during incubation.

In studying problems of nutrition as well as other questions which pertain to the vital processes of the living organism the investigator is at a disadvantage, since he can seldom watch the changes going on inside the body. He is, therefore, usually compelled to depend for information on variations in various factors which are capable of exact measurement. For instance, the variations in the amount of nitrogen excreted in the urine have been long accepted as throwing light upon changes which take place in the body in the digestion and assimilation of this food constituent, and measuring the balance of income and outgo of nitrogen has been looked upon as an important aid to the study of many problems of metabolism. In justice it must be said that while data of this character rightly accumulated and rightly interpreted are of great value, too often the accumulation of such information does not represent any advance in theory or in practice. There are many digestion experiments with farm animals which have been accompanied by a determination of the balance of income and outgo of nitrogen in which no use was made of the data thus accumulated, the experimenter's idea being obviously that such figures were worth accumulating for their intrinsic value. It seems not inappropriate to suggest that a better knowledge of the possibilities of experimental work and of the use of experimental data would have resulted in the accumulation of more valuable material.

Since the time of Sanctorius, who lived early in the seventeenth century and may be called the father of respiration experiments, it has been realized that the respiratory products varied in character and amount with a variety of conditions, and as experimental methods have improved it has been realized that the study of variations in the kind and amount of respiratory products afforded a valuable means of judging of the changes which took place in the body, particularly those which had to do with metabolism. Numerous forms of respiration apparatus have been devised for this purpose, the Pettenkofer type, evolved in Munich, having been often used in experiments with animals.

A great advance was made in this kind of experimenting when Atwater and his associates[a] devised a respiration calorimeter which measures the income and outgo of energy as well as of matter. This type of apparatus has been adapted to experiments with farm animals by Armsby[b] and his associates at State College, Pennsylvania, in cooperation with the Bureau of Animal Industry of this Department, and a series of investigations begun, important both with respect

[a] U. S. Dept. Agr., Office Expt. Stas. Bul. 41.

[b] U. S. Dept. Agr., Bur. Anim. Indus. Bul. 51.

to the contribution they make to the theories of nutrition and to practical questions as well.

In respiration experiments of the sort to which reference has been made total quantities are taken into account. In another type of respiration experiment the ratio of oxygen taken into the lungs to carbon dioxid liberated, i. e., the respiratory quotient, is the factor which is measured. It has been found that the respiratory quotient varies with a great variety of conditions and that it is a very delicate index of changes which take place in the body. To Zuntz, more than to any other investigator, should be ascribed the credit of evolving this method of studying physiological problems and of applying it with great skill. Such questions as the relative energy expended in the body in digesting different nutrients and other topics equally important are among those which he has studied. His experimental methods might well be followed at American experiment stations in the study of animal nutrition problems.

Perhaps no question in physiological chemistry is of more interest at the present time than that of enzyms, and it sometimes seems as if these unorganized ferments, as they are often called, were the real causes of most of the physiological activity of both ants and animals. The digestive ferments, it is needless to say, have long been known and often studied, and the great interest now being manifested in the whole question has led to a great many new investigations with these particular enzyms and to a far greater number with the enzyms concerned in the other problems of animal biology.

Euler [a] has recently published an exhaustive summary and critical study of available data regarding enzyms, including such questions as their chemical nature, classification, and preparation, the influence of temperature on enzym activity, the products of enzym activity as preventives of enzymic action, and the function of activators or coenzyms. His report will well repay careful study, and familiarity with this and other enzym literature should lead station investigators to the study of some of the important questions.

The question of the amount of protein actually required by the body under different conditions can not be solved until we know the ways in which the body uses nitrogenous material. We are accustomed to say that it is required for growth of the body and for development, and for replacing tissue which is broken down by vital processes—for instance, to replace the nitrogenous tissue lost as hair, epithelial cells, intestinal mucus, and so on.

In studies of the chemical dynamics of animal nutrition, Schryver,[b] an English investigator, has emphasized the importance of protein,

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[a] Ergeb. Physiol., 6 (1907), p. 187.

[b] Bio-Chem. Jour., 1 (1906), p. 123.

his general conclusion being that the function of nitrogenous foodstuffs in nutrition is to produce enough ammonia in the digestive tract to maintain intracellular alkalinity of the liver and probably of other tissues also. "The production of nitrogenous degradation products," he concludes, "proceeds at such a rate that there is never a dearth of nitrogenous bodies in the blood stream, and the bioplasm of the tissues, especially the mucous membrane of the small intestine, can remain saturated with side chains, for we have seen that the liver of a fasting animal contains more residual nitrogen than does that of a well-fed animal."

From the researches which he reports he believes it is shown that while the animal derives most of its energy from the oxidation of carbohydrates and rapidly eliminates nitrogen from albumins, the latter, nevertheless, play an important rôle in nutrition, for the cleavage products are needed not only to satisfy, as Folin [a] has suggested, the needs of endogenous metabolism of the organism representing the wear and tear of the tissues, but also to supply sufficient ammonia to maintain a certain amount of general intracellular alkalinity. In the absence of this needed amount, nitrogenous equilibrium ceases to be maintained.

The number of problems relating to enzymic action to digestive processes, to the function of nutrients, and other topics which have been studied by laboratory methods is very great, but much remains to be done.

A large amount of work pertaining to the chemistry of cells and organs which is of decided interest to students of farm-animal problems has been done in the physiological laboratories of Yale University by Chittenden and Mendel and others associated with them.

The bearing on animal nutrition, and particularly the nutrition of farm animals of work, which Mendel [b] has recently reported, is shown by experiments on the chemical changes involved in the growth of the animal body, particularly pigs and poultry. These investigations have to do with the composition and chemical changes which are characteristic of developing organisms and the equipment of such organisms for utilizing the nutritive materials presented to them. The investigations with hens' and ducks' eggs incubated for different periods have furnished new evidence regarding the synthesis of purins in embryonic life, the fresh egg being practically free from purins. In the case of pig embryos in comparison with adult pigs it was found, for instance, that the developing muscle tissues which contain glycogen during embryonic life give evidence during the early stages of this period of a relatively greater glycogen digesting power

[a] Amer. Jour. Physiol., 13 (1905), p. 117.

[b] Amer. Jour Physiol., 20 (1908), pp. 81, 97, 117; 21 (1908), pp. 64, 69, 77, 85, 95, 99.

than that of the liver tissues, while the embryo liver, which is in the early stages free from glycogen, only gradually acquires its characteristic digestive capacity. In general, Mendel found that analyses of water-free and fat-free tissues of animals fed on diets of widely different character indicate the tendency of the tissues to maintain a constant chemical character.

The deductions which can be drawn from such experiment work and other evidence furnished by investigations of similar character lead to the belief that eventually theories of nutrition can be formulated of such a definite character that animal feeding will become a matter of certainty instead of "cut and try," as it is at present.

Twenty-five or perhaps even ten years ago it might have seemed visionary to suggest that it would be possible to discuss with any definiteness the features which cause, for instance, the secretion of digestive juices and the formation of milk, or to have explained in chemical terms the way in which the food elements become a part of the living body. So great progress has been made, however, that reasonable explanations are now offered which are well grounded on experimental evidence. The work on which such theories are based has been most often undertaken as a part of studies in human physiology or medicine, but the results are applicable to animal feeding. Pavlov's[a] work on the physiology of digestion is generally regarded as one of the most important contributions to the subject which has been made in a long time. He has gone a long way toward explaining the different steps in natural digestion and the chemical and other factors which are the direct causes of digestion. His work, while highly technical, is fundamental to the understanding of everyday problems of nutrition.

Perhaps no field offers a greater reward to the investigator than that in which Starling[b] and his associates in the physiological laboratory of the University of London and other investigators have accomplished so much. According to modern views, as set forth in a recently published paper of Starling's, body activities are due to two sorts of influences, namely, nervous and chemical. When the reaction occupies a very short time, being a question of seconds, it is assumed that the nervous system is employed to produce it. When it is a question of longer time, however, it is a matter of chemical activity. The chemical reactions or adaptations of the body, like those carried out with the aid of the central nervous system, may be divided into two main classes—those which are brought about in consequence of changes impressed upon the organism as a whole from without and those which, acting entirely within the body, serve to correlate the

[a] The work of the Digestive Glands. London, 1902.
[b] Sci. Prog. Twentieth Cent., 1 (1907), p. 557.

activities, in the widest sense of the term, of the different parts and organs.

The first class would include the reaction of the body to chemical poisons by bacteria or otherwise, and in this connection the complicated phenomena involved in the formation of antitoxins, of bactericidal substances, and such matters would be concerned. This part of the subject has been more readily approached and has been more extensively studied than the second, which has to do with the specific chemical action on some part of the body of materials produced within the body. That this is a subject of great moment is obvious when the importance of the active constituent of the thyroid gland is recalled. It is known that the absence of this principle of the thyroid gland is a cause of cretinism and idiocy in children, and that this condition is often helped by the use of this substance as a remedial agent. The active constituent of the suprarenal capsule, which is generally referred to as adrenalin, is another instance of the great importance of body constituents which were formerly overlooked. The total amount of adrenalin present is small, even in such animals as cattle, and yet if absent in man a serious disease results. It is very largely owing to the efforts of Abel, of Johns Hopkins University, that the chemistry of adrenalin has been worked out and this substance added to the pharmacopœia. The key to many perplexing problems of animal feeding may lie in such constituents of the body.

Perhaps even a more striking instance of the importance of these chemical stimulating bodies, the "Reizstoffe" of the Germans, or, to give them the English name which has been proposed for them, hormones, is found in the investigations which have to do with milk secretion. Carefully conducted experiments carried on by Starling[a] and his associates indicate that the body elaborates a specific chemical compound which has the power of exciting activity in the mammary glands, and that this may be isolated from an animal where it has been naturally formed and will produce the activity of the mammary glands in another female animal under the proper experimental conditions.

Theories have been formulated which explain such body processes. It is believed that the body cells contain a protoplasmic molecule as a living nucleus to which are linked side chains of various descriptions. Thus, when food elements are brought in the blood stream they are linked as side chains to this nucleus, and so an explanation of the nature of body nutrition is offered. When side chains are of a different character stimulation is brought about. This theory has

[a] Lancet [London], 169 (1905), pp. 339, 423, 501, 579; Proc. Roy. Soc. [London], 77 (1906), p. 505.

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been discussed at length by a German investigator, Ehrlich,[a] and his reasoning is comprehensive and logical. His work should be mentioned, as it shows that there is hope of approaching by chemical methods the problems which are concerned with all questions of body growth and activity.

Without doubt the greatest mystery which we encounter in any study of the living body is the question of the dynamic forces which we call life. From time to time some investigator pushes forward into this subject and explains in physical or chemical terms the nature of some reaction which has perhaps hitherto been considered inexplainable. It is a matter of pride that some of the most important work along this line has been carried on at several of our American universities by Loeb.[b] Not long ago he published a résumé of his work, entitled "The Dynamics of Living Matter," in which his investigations in experimental biology are summarized with reference to such questions as the general chemistry of life phenomena, the general physical constitution of living matter, some physical manifestations of life, the rôle of electrolytes in the formation and preservation of living matter, and facts concerning fertilization, heredity, and the dynamics of regenerative processes.

Animal production—that is, the feeding of farm animals for economic purposes—is nothing more than an attempt to influence growth, development, the production of energy, or some other body processes, and so produce results which are desired. No one can reasonably believe that it will be possible to control definitely such processes until the whole subject is thoroughly understood from a scientific standpoint. It is a far cry from fattening a pig for market to laboratory investigations of hormones, and nuclei with their side chains, and the theories of toxins and antibodies, and similar questions, but here, as elsewhere, the practical is dependent upon the scientific. Just as no manufacturer who has to dye thousands of bolts of silk a particular shade would depend to-day upon the crude dye pot of earlier times if he expected his results to be uniform, so the feeder of the future will not depend upon empirical knowledge and rule-of-thumb recipes, but will use exact methods which have been discovered as a result of laboratory work. Even if he does not understand all the processes involved, he will be able to apply the deductions of investigations in such a way that he may produce definite results.

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[a] Collected Studies on Immunity. London and New York, 1906.

[b] The Dynamics of Living Matter. New York, 1906.

REVIEW OF TEN YEARS OF IRRIGATION INVESTIGATIONS.

By R. P. Teele.

The season of 1908 completed ten years of irrigation investigations by the Office of Experiment Stations, and this seems a fitting time to review the work of the past, summarizing the data collected, and see what progress has been made, not only in the investigation, but in irrigated agriculture as well. The work of irrigation investigations was provided for in 1898, when Congress appropriated $10,000 "for the purpose of collecting from agricultural colleges, agricultural experiment stations, and other sources * * * valuable information and data on the subject of irrigation and publishing the same in bulletin form." This action was taken in response to a demand from the irrigated sections for help in a situation which had become very much involved. Modern irrigation in the western portion of the United States began with the Mormon settlers in Utah in 1847, and developed gradually as settlement spread for the next third of a century. During this time the Middle West was settling and there was no great demand for irrigated lands. Development was normal, canals being built as they were needed and not far in advance of settlement. About 1880 attention was attracted to the success of irrigation in the arid region, and led on by the great increase in land values, due to irrigation, capital rushed into this field and a great many large canals were built far in advance of any effective demand for land. The ditch builders could not secure title to the land covered, because it was public land and could be secured only by settlers and in small tracts, but the investors hoped to secure the increase in land values indirectly by selling to the settlers so-called "water rights." The settler could secure land from the Government under the homestead law by making his home upon it, or under the desert-land law by bringing it under irrigation and paying $1.25 per acre. But he could not maintain a home or secure his land under the desert-land law without the water which was to be supplied by the canal. For this reason the promoter thought the settler could not do without him, and was therefore at his mercy. He overlooked the fact that he could not do without the settler; that the settler had only to stay away and the canal builder had only a ditch, the cost of maintaining which would soon exceed its cost of construction. And the settlers

did stay away, or came so slowly that most of the large canals were financial failures.

The building of so many canals had other effects. It proved the inadequacy of the water laws of the Western States. Most of these States early recognized the right of appropriating or diverting water from streams for beneficial use and that among appropriators the first in time was the first in right, but they did not provide a means of determining the extent or date of appropriations, or any agency for protecting the earlier appropriator against later comers. Along many streams the capacity of the canals built exceeded the flow of the streams. In theory the beneficial use of the water diverted was essential to the establishment of a right. Since some of the canals were unused and almost none was used to its full capacity, there was great uncertainty as to what rights had been acquired, and this uncertainty could be removed only by appeal to the courts, which had no well-defined principles and no technical knowledge on which to act. Appeals to the courts under such circumstances very often increased the confusion instead of creating order. This confusion regarding water rights was the dominant feature of the irrigation situation in the arid region at the time of the beginning of the irrigation work of this Office, and it was the controlling influence in determining the nature of the work undertaken at that time. Before the work was begun a conference of experiment station officers and irrigation engineers who had been prominently connected with western irrigation development was held in Denver, and was attended by officers of the experiment stations of California, Colorado, Montana, Nebraska, Utah, and Wyoming, and by the State engineers of Colorado, Nebraska, and Wyoming, besides representatives of the United States Department of Agriculture. At this conference it was decided that the best results could be obtained by carrying out this work along two general lines: (1) The collection and publication of information regarding the laws and institutions of the irrigated region in their relation to agriculture, and (2) the publication of available information regarding the use of irrigation waters in agriculture as shown by the actual experience of farmers and by experimental investigations, and the encouragement of further investigations in this line by the experiment stations. The work was organized according to these suggestions, and was, therefore, divided into two classes, the legal and economic and the cultural. Following the conference, the work was placed under the direct charge of Elwood Mead, at that time State engineer of Wyoming. This action was indorsed by Congress at its next session, when it provided for the investigation of (1) "the laws and institutions relating to irrigation" and (2) "the use of irrigation waters, with especial suggestions for better methods for the utilization of irrigation waters in agri-

culture than those in common use." The appropriation for the work was increased to $35,000.

The laws and court decrees of the arid States and Territories were collected and abstracted and the water rights decreed by the courts were studied in connection with the streams and canals to which they related, bringing out the fact that as a rule there seemed to be no relation between the flow of a stream and the sum of the rights to water from it, and little relation between the capacity of a canal and the quantity of water decreed to have been put to a beneficial use under it. These facts were attributed to two causes—rotation in use, and lack of knowledge as to flow of ditches. Each user of water from a stream was decreed a right to the largest volume of water he claimed to have used or diverted at any one time. No one party used water continuously, the stream being used in turn by the several appropriators, so that the sum of all rights might be several times the flow of the stream without misrepresenting the facts. Each appropriator was held to have a right to the continuous use of a stream of the size allotted to him, but in fact he did not use it continuously, the practical effect being that the first appropriator could use water whenever he wished, the next appropriator could do the same except that he must not interfere with the prior appropriator, and so on, each in turn taking water whenever he chose except as it interfered with prior rights. As lands were taken up this intermittent use tended to become continuous, adding greatly to the value of early rights and subtracting from the value of later rights in the same proportion. This enlargement of use under early rights has worked great injustice to the holders of later rights, and has caused much criticism of the courts rendering the decrees which permitted it. But the injustice is due to developments subsequent to the decrees rather than to the ignorance or viciousness of the courts. Applied to conditions existing when they were rendered, the decrees did no injustice to anyone.

As a rule, neither claimants nor courts were expert in the measurement of water, and the amounts decreed were based upon guesses as to what canals would carry rather than measurements of any kind. So long as there was water enough for all the quantity decreed to anyone was a matter of indifference. For these reasons the decreed rights and the sizes of ditches had no apparent relation. As the demand for water has increased, all these inaccuracies have come to light and have been made the basis of more or less violent criticism of the courts and have led to vigorous protest against the adjudication of water rights by the courts. But, as in the other case cited, the injustices complained of are due to developments which brought into prominence factors which were unimportant or negligible when the decrees were rendered.

Be that as it may, the first work of this Office was directed mainly toward the correction of these abuses. In theory water rights are based upon beneficial use, and measurements of the quantities used in general practice throughout the arid region to determine how much water was beneficially used per acre were made in the hope that this information would be used by courts in adjudicating rights. At least the information would be available so that the courts could make use of it.

To repeat, then, our early investigations of the laws and institutions relating to irrigation showed the following weaknesses in the operation of existing laws:

(1) Most of the existing rights to water were undefined.

(2) Many decrees defining rights were manifestly unjust.

(3) There was not adequate provision for protection of rights.

(4) There was not sufficient supervision of the acquirement of rights to insure a definite knowledge of what rights were secured.

All of these weaknesses can be traced to a single source—the conception that water-right adjudications are private controversies in which the States had no more interest than in suits over any other class of property. There were commonly requirements that any party diverting water from a stream post and file a notice stating what was claimed, but no provision for any determination of whether such claims had ripened into rights until controversy arose between different claimants, when the respective rights of the claimants were defined by the court. A development from this was a provision for making all parties taking water from the same source parties to any action for defining water rights. But after such an adjudication new claims might arise, making necessary new adjudication. Under such a system no defining of rights could take place until controversy arose, and after an adjudication took place the rights could not be considered settled. No right was absolute, but relative to some other rights.

In adjudications the public was not represented, the decrees being based on interested testimony and often on stipulations agreed upon by the parties, so that they were in effect a division of a public resource among themselves by a few parties who, under the accepted doctrine of water rights, were entitled only to rights to so much water as they had put to a beneficial use. In almost no case were the decrees based on any exact knowledge of the capacities of ditches, the quantities actually diverted, or the needs of the lands served.

In only a few States was there provision for the appointment of officials to enforce water-right decrees, and in some States the only recourse when decreed rights were violated was a contempt proceeding. New rights were acquired by diverting and using water and posting and filing notices without public supervision, so that even

when all existing rights to a stream were defined the list might at any time be made incomplete by the construction of new works.

To remedy these evils the earlier bulletins of this Office recommended the adjudication of all existing rights by administrative boards, their decisions being based on surveys and measurements made by public officials and the testimony of the parties interested; the division of streams among those entitled to water by public officials and the acquirement of rights under such public supervision as will define them as they are acquired. In other words, they recommended that the acquirement and protection of water rights be considered a public matter rather than a private matter.

At the time this work began the ideas advocated in our bulletins were largely embodied in the constitution and laws of Wyoming and in the laws of Nebraska. Colorado had one feature, the distribution of water by public officials, but outside of this the system proposed was not in force in any of the arid States and Territories. From the fact that this system was adopted first in Wyoming it has been quite generally known as the Wyoming system.

The Wyoming constitution and laws provide for the appointment of a State engineer and four superintendents of water divisions, who together shall form the State board of control, and for the appointment of water commissioners to distribute water to those entitled to its use. The board of control is charged with the adjudication of existing rights, the water commissioners, under the direction of the superintendents of divisions and the State engineer, distribute water, while the State engineer supervises the acquirement of new rights until they reach the stage where proof of diversion and use must be made, when the board of control passes upon them.

Before the adjudication of rights to water from any stream is undertaken the State engineer makes surveys of the stream, the ditches diverting water from it, and the adjoining lands. The superintendent of the division in which the stream is located then collects sworn statements of all claims to rights, takes testimony as to dates of first use of water, hears contests, and prepares a list of rights. This list is submitted to the board of control, which prepares a formal decree defining all rights, and issues certificates of rights to the claimants. These certificates are mailed to the clerk of the county in which the irrigated lands are located, where they are recorded and then mailed to the claimants. Appeal may be taken from the decisions of the board of control to the courts. This provides for a complete list of rights existing at the time of adjudication.

Parties wishing to divert water from streams must apply to the State engineer for a permit to make the diversion, and may not begin construction until permit is secured. The permit fixes the time within which the water must be diverted and used, and before the

expiration of the time the applicant must submit proof of having complied with the conditions of the permit. This proof is submitted to the division superintendent in the same manner as for a previously acquired right, and by him submitted to the board of control, which issues a certificate defining the right, if the works have been completed and the water used as set out in the permit. There is thus provided a complete list of rights for the guidance of the water commissioners in distributing water from streams.

This system, with slight changes, was adopted in Nebraska in 1895, before the beginning of the irrigation work of this Office. In its general outline it was adopted in Nevada in 1905, the principal change being that the State engineer alone makes the adjudications, from which appeal may be made to the courts.

The same system, with one important change, has also been adopted in the years 1903 to 1907 in Idaho, Utah, North Dakota, South Dakota, Oklahoma, and New Mexico, while Oregon adopted it in 1909. In these Commonwealths it is held that the adjudication of rights is a judicial matter which can not be committed to an administrative officer or board, but must remain in the courts. However, they attempt to secure the advantages of an administrative adjudication by providing in most of the States that the engineer shall make the surveys and measurements and collect the claims as provided by the Wyoming law, and submit this to the attorney-general, who shall bring suit on behalf of the State to define the rights. This provision is based on the theory that the water belongs to the State or to the public, and that the State either as owner or as trustee for the public is an interested party, empowering it to bring such suit. This view has been overruled by the Idaho supreme court, and the State can not force an adjudication. The Idaho law now provides that when suits involving water rights are instituted the court may call upon the State engineer for surveys, etc. The laws of North Dakota, South Dakota, Oklahoma, and New Mexico contain the provision which was overruled in Idaho, but in these States it has not been passed upon by the courts. If their courts follow the Idaho court it will seriously retard the securing of full lists of rights, since no defining of rights can take place until suits are brought by interested parties. If existing rights are not defined, the engineer can have no basis for determining whether new rights may be granted and the water commissioners can have no guide for distributing water.

The one weak point in these laws is the point at which they have departed from the Wyoming system, although it may be that under the constitutional limitations of these States an administrative adjudication is not possible. In Wyoming the provision for this is in the State constitution, but no other State has such a constitutional

provision. In Nevada the raising of the question of the constitutionality of an administrative adjudication has been avoided by the State engineer submitting his findings to a court and having them issued as a decree of the court, instead of issuing them as a decree of the engineer, from which appeal might be taken to the court.

One important departure from the system originally advocated by this Office has been made in Wyoming, as well as all the States adopting codes within the last decade. This relates to transfers of water rights from one piece of land to another. The dangers of the monopolizing of rights to water by nonusers, with the possibilities of the exploitation of the water users by the owners of the water rights, led to the enactment of laws making water rights appurtenant to the lands in connection with which they were acquired and prohibiting their transfer apart from the land. It seemed self-evident that under such laws the holding of a water right apart from land was impossible, and consequently the existence of "water lords" was prevented. But the economic disadvantages of attaching rights to lands which might prove to be worthless or inferior to other lands on which the water might be used have led to the repeal or modification of such laws in such a way as to allow of transfers under much the same public supervision as is given to the acquirement of new rights.

Washington and Montana have had commissioners appointed to draft new codes of water laws, and it is probable that within a few years these States will have adopted codes embodying the general principles advocated in the earlier publications of this Office.

The great progress made in the enactment of better water laws during the last decade has led to a lessening of the emphasis laid on that line of work by this Office. It is probable that the future will develop conditions which demand changes in the newer irrigation laws, and our studies of the operation of these laws will be continued and reports will be published as there is demand for them.

Aside from the effect of laws upon investments and upon settlement, it has been found that the character of the laws has a marked influence upon the economical use of water. The water laws of the arid States are of two general classes, considered from this point of view, those which allow of the acquirement of rights to definite quantities of water and those which limit rights to the necessities of a definite tract of land. Under laws of the former class canal owners are free to use their water supply on as large or as small an area as seems to them best, and since the more economically the water is used the larger area it will serve and the larger returns it will bring, every consideration leads to an economical use of water. Canal owners receive the direct benefit of their economy. Under laws of the latter

class, limiting rights to the needs of a particular tract of land, with a maximum limit fixed, as in Wyoming and Nebraska, there can be no incentive to economy, since any water made available by economical use goes to others than the one making the saving. The inevitable tendency is for farmers to use as much as possible within the maximum fixed, in order that they may not by present economy decrease their supply for future needs. The laws of all the arid States prohibit waste and authorize the water officials to stop waste, but between positive waste and the most economical use there is a wide margin. This system has the added disadvantage of making rights indefinite. When prior rights are fixed at a definite quantity of water, subsequent appropriators know what may be taken by the prior appropriators and can estimate fairly well their own chances for water, but under the other systems a change in the type of agriculture by prior appropriators may so enlarge their use as to destroy entirely the value of later rights.

WATER-RIGHT CONTRACTS.

The water laws of the States define the rights of canal owners. Most farmers are not directly canal owners, but secure rights from the companies or individuals owning canals. The contracts under which such rights are secured and the regulations adopted by canal owners stand in the place of water laws to the farmers. The prevailing type of contract is one in which the company agrees to furnish a fixed quantity of water, which, however, must be used on a definite area, and subject to the further limitation that whenever there is not water enough to give to all their full contract quantities the available water shall be prorated. In effect these contracts provide that the farmer shall take what water he can get, for which he shall pay a flat rate per acre, regardless of the quantity received. The only economy which can be expected under such a contract is such as is enforced by the canal company contracting to deliver more water than it can get, and then prorating its supply. A few companies deliver water on a quantity rate, with a fixed minimum charge, and it has been found that farmers securing water under such contracts use much less water than those paying a flat acreage rate—in two instances, where accurate measurements were made, the saving was more than 25 per cent. Under such a contract the water user is directly benefited for his saving by a decrease in his water bills. The water companies should be guaranteed enough income to cover their fixed charges, and the minimum rate provides for this. The economy begotten by the quantity rate enables the company to serve a larger area than otherwise, and this insures a large area from which to collect the minimum charge.

THE ORGANIZATION OF IRRIGATION ENTERPRISES.

At the time of the beginning of the irrigation work of this Office the most common type of irrigation company was the one selling water rights to farmers under contracts like those just described. The receipts from the sale of rights were expected to repay the cost of construction with a good profit, and annual charges sufficient to pay for operation and maintenance were provided for. The manifest unfairness of the terms of the contracts was probably responsible for much of the fear of "water lords" previously mentioned. This, and the fact that companies of the type described were usually financial failures, have led to changes in which the farmer is given a better bargain. The old contracts were modified by adding a provision that when the water rights were all sold the canal property would be turned over to a stock company composed of the water users, the stock to be issued in exchange for the water-right contracts. These stock companies are now the most common type throughout the arid region. Both the State laws accepting the terms of the Carey Act and the Reclamation Act provide for works built under these laws being turned over to such companies. In addition, most of the States have enacted irrigation district laws under which many of the old ditches are being bought in by the water users and operated by them as mutual concerns. Home rule in irrigation is, therefore, practically assured under every type of organization. Here, then, as in the field of irrigation law, the evils most prominent at the time of the beginning of our work have disappeared.

DUTY OF WATER.

Although the measurements of the quantities of water used in general practice made by this Office during the first few years of its work were primarily for the purpose of giving courts and public officials an intelligent basis for decrees as to the extent of water rights acquired, they served other purposes. There was a large demand for such data to be used by irrigation engineers in designing and building irrigation works, by officials of canal companies in drawing up water-right contracts, and from settlers who were asked to sign these contracts, and who wished to know whether the supplies fixed in the contracts were sufficient for their needs. Without such knowledge the engineer could not determine how large a canal to build to supply a certain area, or, having determined the quantity of water available and the cost of bringing it to a tract to be irrigated, he could not decide upon the practicability of his scheme because he could not determine how large an area his water supply would serve. This was strikingly brought out in the estimates of the areas which could be

irrigated, made before the passage of the Reclamation Act. The advocates of that law based their estimates upon a supply of 1 acre-foot per acre, while our measurements of the quantities used showed a use of more than 4 acre-feet per acre on an average. As a result, estimates of the ultimate irrigated area have decreased from 75,000,000 and 100,000,000 acres to 30,000,000 and 50,000,000 acres, and the estimated cost of irrigation works per acre has increased in about the same ratio. Promoters were likewise at sea. Works planned to serve large areas actually supplied only half the lands, leaving the cost to be apportioned upon an area too small to meet it.

Realizing the great need for such data, this Office began in 1899 systematic measurements of the quantities of water used in general practice under typical canals in New Mexico, Arizona, California, Nebraska, Colorado, Wyoming, Montana, Utah, and Idaho, and in the years immediately following the measurements were extended to the other States of the arid region. Local differences were expected, but it was hoped to get general averages which would prove valuable for general estimates and at the same time secure a sufficiently large amount of local data to enable parties to determine approximately the quantities of water required for crop growing in any part of the arid region. These general measurements were continued through the season 1904, when it seemed that the purpose of such a general study had been accomplished.

The measurements were made by means of weirs in some instances and of measuring flumes in other instances. Rating tables were prepared for the flumes by current-meter measurements and weir tables for both rectangular and trapezoidal weirs of different lengths were published.[a] Automatic registers for making continuous records of depths over weirs and in flumes were installed wherever measurements of water were made, and discharges were computed from the record sheets taken from these instruments. The registers in existence at the time this work was begun were expensive and in many cases not adapted to the conditions under which they were to be used, and a large amount of experimenting was done in the hope of developing cheaper and better instruments, which would help to popularize the practice of measuring water, as well as aid in our own work. Considerable was accomplished along this line, especially in cheapening the instruments and securing their more general use.

Three classes of measurements were made: (1) At the heads of large canals, to secure what has been termed the gross duty of water; that is, the volume which must be diverted from a stream to supply a given area, and which includes all losses in conveyance to the place of use. (2) At the heads of laterals, which include losses in the

[a] U. S. Dept. Agr., Office Expt. Stas. Bul. 86.

distributing system to the margins of the fields. (3) At the margins of fields, to secure what may be termed net duty; that is, the volume of water actually applied to the lands. A comparison of the results from the three series of measurements should segregate the losses in conveyance in two sections, those in the main canals and those in the lateral systems. In practice, however, the results are difficult to interpret, because some laterals are larger than some main canals, and soil conditions differ so widely that a comparison of results from different canals, based on measurements alone, without an exact knowledge of other conditions, is sure to be misleading. The results, however, proved of great value, and are summarized in the following pages.

GROSS DUTY OF WATER.

As just stated, the total quantity of water diverted per acre of land irrigated has been called the gross duty of water in irrigation. This includes all losses in conveyance, and in some cases waste back into the stream. In preparing the table which follows no attempt has been made to average all measurements taken, but the intention is to give results from sufficient areas to represent general practice in the localities mentioned.

Gross duty of water, by streams.

Stream.	Canal.	Approximate area irrigated.	Water diverted per acre.
		Acres.	*Acre-feet.*
Arizona: Salt River	Average of several	113,000	3.42
California:			
Santa Ana	Gage	7,000	2.16
Santa Clara	Average of several	5,160	2.00
Tule	do	5,000	4.94
Tuolumne	Modesto	7,000	13.18
Do	Turlock	20,000	8.34
Cache Creek	Moore	7,000	3.15
Colorado:			
Arkansas	Amity	16,000	4.92
Do	Lake	15,000	2.58
Grand	Grand Valley	22,000	4.11
Cache la Poudre	New Cache la Poudre	30,000	2.21
Big Thompson	Average of two	32,000	1.80
St. Vrain	Supply	7,000	1.79
Clear Creek	Average of three	53,000	1.37
South Platte	Average of several	67,000	2.90
Montana:			
Gallatin	do	8,000	3.55
Yellowstone	Big Ditch	25,000	2.71
Bitterroot	Average of several	20,000	4.69
Nevada: Truckee	Orr Ditch	6,000	7.08
Nebraska: North Platte	Average of several	80,000	4.00
New Mexico: Pecos	Pecos	8,500	7.90
Utah:			
Big Cottonwood	Average of several	8,000	4.13
Logan	Average of two	6,000	4.08
Bear River	Bear River	17,000	4.84
Washington:			
Naches	Average of several	15,000	4.86
Yakima	do	50,000	5.70
Wyoming:			
Laramie	Canal No. 2	6,500	3.72
Deer Creek	Average of several		10.40
Horseshoe	do		9.75

While the measurements reported represent general practice, they need explanation in order not to convey wrong impressions. Some represent settled conditions, while others represent lands just being brought under irrigation. In general, the quantity of water diverted by new canals per acre irrigated is much larger than that diverted by older canals. New canals lose more water by seepage, new lands require more water, and since only a part of the lands to be served is watered, there is usually plenty of water. All these circumstances combine to make the quantity of water diverted by new canals, per acre irrigated, much larger than that diverted by older canals. The Sunnyside Canal in the Yakima Valley, Washington, illustrates this clearly. For that canal there are records covering six years, during which the area irrigated has steadily increased, while the quantity of water diverted per acre has steadily decreased. This is shown in the following table:

Duty of water under Sunnyside Canal.

Year.	Area irrigated.	Quantity of water per acre.	Year.	Area irrigated.	Quantity of water per acre.
	Acres.	*Acre-feet.*		*Acres.*	*Acre-feet*
1898	6,883	11.4	1901	14,964	9.6
1899	8,497	10.6	1902	18,870	9.1
1900	10,947	10.2	1904	32,000	6.0

During the sixth year only a little more than half as much water per acre was diverted as in the first year. It is altogether probable that this decrease will continue until the enlargement of the area forces economy, when a settled condition of careful use will come.

The Salt River Valley in Arizona has been under irrigation for many years, and measurements reported probably represent the requirements of land in that section under present practice.

The Gage Canal is representative of the citrus-growing sections of southern California, which have been under irrigation for a number of years. Most of the water is pumped; it is carried to the irrigated section in a cement-lined canal; is distributed to the fields in underground pipes, and the application of water is followed by careful cultivation to prevent evaporation. The measurements reported, therefore, represent very closely the actual requirements of citrus groves in southern California. The Santa Clara Valley is devoted largely to deciduous fruits. Some orchards receive water from creeks during the spring only, some receive pumped water during the summer, while some receive no water except rainfall. The measurements represent water received from creeks, and all was used between February and June.

The Modesto and Turlock canals are new and the lands are just being brought under irrigation. This accounts for the very large quantities used. The same is true of the Moore Ditch from Cache Creek.

In Colorado the canals from Cache la Poudre and Big Thompson rivers and St. Vrains and Clear creeks represent settled conditions where the irrigated area has been extended to the limit of the water supply, and where a very large part of the flood flow is stored and used. The canals from the Arkansas and South Platte rivers represent an earlier stage of development, while in the Grand River Valley the water supply is so large that economy is not necessary.

The Montana canals reported all represent settled conditions, although a greater demand for water will undoubtedly bring about a more economical use.

The Orr Ditch in Nevada probably represents very fairly practice in that State, where agriculture has not reached a high stage of development.

The Nebraska ditches reported are representative of the North Platte Valley, the principal irrigated section of the State. Agriculture in this section is rapidly developing and a more economical use will result.

The measurements in the Pecos Valley, New Mexico, were made several years ago, when the lands were just being brought under irrigation, and do not represent settled conditions.

The big Cottonwood and Logan River measurements in Utah represent lands long in cultivation, while the Bear River lands are much newer, although there is no marked difference in the quantity used.

The Yakima River measurements have been discussed previously. The Naches River measurements represent more settled conditions.

Canal No. 2 of the Wyoming Development Company, taking water from Laramie River, represents the most advanced irrigation development in Wyoming, and the quantity used is probably about what is required under good irrigation practice in that State. The measurements on Deer and Horseshoe creeks represent the irrigation of native-hay meadows on creek bottoms, where much of the water merely flows over the land and back into the streams. The measurements do not indicate the quantities of water needed even for gravelly bottom lands.

From the above measurements it appears that 3.5 to 4 acre-feet per acre per year is required at the heads of unlined earth canals after conditions have become settled. This can safely be taken as a basis for computations, since when canals are new only a part of the lands to be served ultimately are watered, and a larger supply is available for the lands actually under irrigation.

DUTY OF WATER UNDER LATERALS.

Not enough measurements of the quantities of water delivered to laterals have been made to justify any attempt at averaging the results. In a few instances measurements at the heads of main canals and at the heads of representative laterals from them have been made, and these are summarized below. In no instance do the laterals measured constitute all those diverting water from the canal, and therefore they may not be representative, although most of them seem to be.

Comparison of quantities of water diverted by main canals and by laterals therefrom.

Canal.	Stream.	Average for canal.	Average for laterals.	
		Acre-feet per acre.	*Acre-feet per acre.*	*Per cent.*
Pioneer	Tule River, Cal	8.01	1.41	18
Amity	Arkansas River, Colo	4.92	1.82	37
Pecos	Pecos River, N. Mex	7.90	3.69	47
Bear River	Bear River, Utah	4.84	1.84	38
Modesto	Tuolumne, Cal	13.18	5.76	44
Turlock	do	8.34	7.69	92
Sunnyside	Yakima, Wash	6.25	4.73	75

It will be noted from the discussion of the gross duty of water that no one of the canals included in this table represents settled conditions. The straight average of the percentages given is 50 per cent, and it is probable that this represents fairly well conditions under canals which have been in use for a few years only. Many new canals deliver much less than this, and older canals deliver a higher percentage. This subject is discussed further under the subject of losses from canals.

NET DUTY OF WATER.

Two classes of measurements have been made which give what might be termed net duty of water—measurements of the quantities delivered to individual farms and those of the quantities delivered to fields or plats each containing a single crop. The measurements of the water used on farms are so few in number, so scattering, and vary so widely that they do not justify any averages. However, the measurements reported are brought together in the following table:

Quantities of water delivered to farms.

State.	Location.	Farm.	Crops.	Water received per acre.
				Acre-feet.
Arizona	Salt River Valley	Vance	Alfalfa and barley	1.98
Do	do	Arizona Experiment Station.	Mixed	5.70
California	Tule River Valley	Several	do	3.19
Do	do	do	Fruits	2.00
Do	California	Sprott	Oranges and lemons	1.55
Do	Under Gage Canal	Cayley	Oranges	1.98
Do	do	Carscaden	do	1.20
Do	do	Gulick	do	2.38
Do	do	Quinn	do	1.98
Do	do	Kennedy	do	2.48
Idaho	Boise Valley, Idaho	Long	Mixed	2.72
Do	do	Wilson	Orchard	1.48
Do	do	Goodwin	Mixed	3.28
Do	do	Purcell	Alfalfa, timothy	2.43
New Mexico	Pecos Valley	Several	Mixed	2.49
Utah	Logan Valley	Cronquist	do	2.59
Washington	Yakima Valley	Evans	do	3.58
Do	do	Lower Rattlesnake	do	4.60
Do	do	Upper Rattlesnake	Alfalfa	3.11
Do	do	Jordan	Orchard	6.03
Do	do	Dunn	Hops	3.43
Do	do	Young	Mixed	10.61
Do	do		Alfalfa, orchard	3.03
Do	Kennewick	Gardens	Orchard and fruit	6.31

In a few cases only are these measurements for individual farms under canals for which there are measurements. These few cases are given in the following table:

Quantities of water delivered to farms.

[Compared with water received by canals.]

State.	Canal.	Farm.	Diverted by canal.	Delivered to farms.	
			Acre-feet per acre.	*Acre-feet per acre.*	*Per cent.*
Arizona	Mesa	Vance	3.81	1.98	52
California	Gage	Several	2.16	1.99	92
Idaho	Ridenbaugh laterals	do	4.79	2.50	52
Washington	Sunnyside	do	9.60	3.96	41

Assuming that the farms are representative, these measurements show what might be expected. The Mesa Canal has been in use for many years and represents settled conditions in the Salt River Valley, and delivered to farms 52 per cent of the water received. As previously stated, the Gage Canal is lined and the water is distributed through underground pipes. By this system 92 per cent of the water reaches the land. The Ridenbaugh Canal has been in use for several years, but the measurement given is the average for several laterals rather than for the main canal. The canal therefore delivers something less than the 52 per cent given. The Sunnyside Canal measurements given were for the season of 1901, when the canal received 9.6 acre-feet of water per acre irrigated, and the farms reported,

except the Young farm, which was evidently abnormal, was 3.96 acre-feet per acre, or 41 per cent of the quantity diverted. This is a comparatively new canal and this is probably a close approximation to the quantity actually delivered.

While the number of measurements reported for laterals and farms is not large, it is believed that they represent fairly well average conditions, that is, that canals in use for a few years deliver to their laterals about 50 per cent of the water received from streams, and that they deliver to the lands about 40 per cent of the water received, and that older canals deliver to the lands about 50 per cent of the water received. Measurements of seepage losses, discussed on pages 371–379, seem to bear out this conclusion.

QUANTITIES OF WATER APPLIED TO CROPS.

The quantities of water used on the leading crops of the arid region under field conditions have been measured in many places throughout the arid region, and the averages for the various crops in the different States and Territories are brought together in the following table:

Water used on different crops.

State.	Alfalfa.	Wheat.	Oats.	Barley.	Potatoes.	Sugar beets.
	Acre-feet.	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*	*Acre-feet.*
Arizona		2.17		1.60	2.10	2.50
California	4.50					
Idaho	2.50	1.05	2.33	1.14		1.91
Colorado						2.40
Montana	1.15	1.43	1.74	1.41		1.46
Nevada	6.85	9.27			7.80	
Utah	2.97	1.48	1.37		1.17	2.24
Washington	3.11					
Wyoming			1.60		3.63	
Average	3.51	3.08	1.51	1.38	3.90	2.10
Average without Nevada	2.65	1.53			2.31	

A second average, excluding the Nevada measurements, is included in the table for the purpose of comparing the requirements of the crops. Much more water is used in Nevada than elsewhere, and the occurrence of Nevada measurements in some columns and not in others destroys the comparison. According to these averages the largest quantity of water is used on alfalfa, the other crops receiving water in the following order: Potatoes, sugar beets, wheat, oats, and barley. This is known to correspond with general practice.

The measurements of the quantities of water used in general practice ceased in 1904, as it was believed that the object of these had been accomplished. These measurements brought out very strikingly two important points: (1) The enormous losses of water in transmission from the streams to the places of use, and (2) the great differences in the quantities used under similar conditions, indicating large losses from excessive use. These facts indicated the lines which future

work dealing with the duty of water should take, and were largely responsible for the nature of the work done since 1904: (1) Determination of the losses in transmission and methods of checking them, and (2) the determination of the water requirements of crops and the limitation of use to those requirements.

LOSSES IN TRANSMISSION.

Many series of measurements to determine the losses from canals have been made. The plan usually adopted is to divide a canal into sections, and for each section measure the inflow at the upper end and throughout the section, if there is any, and the outflow through diversions in the section and at the lower end. The difference between the inflow and the visible outflow represents the loss by seepage and evaporation. The making of the measurements on a single section occupies but a few hours at most, so that the loss by evaporation is negligible, and the entire loss is charged to seepage.

In computing the percentage of loss it is customary to determine the ratio between the loss in each section and the inflow of that section, but the percentages of loss per mile given in the table which follows are based on the total loss and the inflow at the head of the canal; that is, these represent the average percentage of the total flow lost in each mile of the entire length measured. The percentages for the separate sections would be larger. The measurements reported have not been very systematic, and as a result the sections of the same canal measured at different times do not always coincide. Therefore the averages are not in all cases based on the same lengths of canal, but wherever measurements are included in an average they represent measurements in the same general section of the canal. All measurements on each canal are included in the averages given in the following table:

Loss of water from canals.

Canal.	Stream.	Number of measurements.	Lengths of sections.	Volume at upper end.	Loss per mile.		
					Maximum.	Minimum.	Average.
			Miles.	*Cubic ft. per sec.*	*Per ct.*	*Per ct.*	*Per ct.*
Arizona:							
Arizona	Salt	Average of three series.	12–6.00	79–113	0.88	0.48	0.72
Consolidated	do	do	4.00	23–125	2.20	.70	1.41
California:							
Collison Slough	Tule	One series	2.50	55.00			5.20
Tipton irrigation district.	do	Two series		75–48	6.80	6.75	6.78
Fine	do	do	1.50	21–32	16.00	11.33	13.67
Vandalia	do	Three series		10–16	64.00	44.50	51.50
Porter Slough	do	Two series		3–97	11.50	.80	6.15
Poplar Ditch	do	Six series		22–73	9.50	2.84	6.01
Plano	do	One series	2.50	7.50			16.00
Pioneer	do	Five series		24–45	2.20	.46	1.47
Pleasant Valley	do	Two series		5–7	11.11	8.60	9.86
S. Tule Independent	do	do		6–8	2.80	2.50	2.65
Ditches in Santa Clara Valley.		Average of several.					6.00

Loss of water from canals—Continued.

Canal.	Stream.	Number of measurements.	Lengths of sections.	Volume at upper end.	Loss per mile.		
					Maximum.	Minimum.	Average.
California—Continued.			*Miles.*	*Cubic ft. per sec.*	*Per ct.*	*Per ct.*	*Per ct.*
Modesto	Tuolumne	One series					0.65
Moore	Cache Creek	Six series		63–167	9.40	0.90	4.70
East Fork	do	Two series		44–108	8.50	5.70	7.10
West Fork	do	do		35–67	13.70	12.60	13.15
Farm ditches	do	Five series		17–30	54.00	8.00	23.70
Capay-Winters	do	Three series		40–80	15.30	1.10	6.40
Central	Sacramento	One series	11.00				3.40
Imperial	Colorado						
Birch lateral		Two series		18–25	1.40	.80	1.10
Beach lateral		One series		7.12			5.90
Dahlia lateral		do		45.40			2.07
Dogwood lateral		do		22.60			4.22
Holt		Two series		13–27	2.40	2.00	2.26
Rose		do		25–37	2.07	1.05	1.56
Colorado:							
Grand	Grand	One series		337.00			+ .13
High Line	do	do		140.00			.38
Lake	Arkansas	do	16.00	456.33			.49
Idaho:							
Twin Falls	Snake	Five series	40.00	840–1,690	1.48	1.01	1.17
Low Line	do	Three series	22.00	133–336	2.68	1.58	1.95
High Line	do	do	40.00	92–225	1.54	1.22	1.41
Montana:							
Big Ditch	Yellowstone	Four series		254–382	1.16	.11	.50
High Line	do	One series	18.51	75.20			1.04
Yellowstone	do	do	7.00	35.60			2.76
Italian	do	do	9.62	50.60			+ .52
Canyon Creek	do	do	12.00	59.72			1.50
Mill	do	do	8.00	29.33			.76
Flaherty Flat	do	do	3.00	21.28			1.75
Merrill	do	do	8.25	30.81			2.07
West Gallatin	Gallatin	Three series		70–114	1.15	.92	1.02
Cameron	do	One series	7.82	26.48			3.60
Farmers	do	do	10.75	133.10			1.64
Kleinschmidt	do	do	17.50	96.11			.55
Republican	Bitterroot	Four series		66–120	2.53	.82	1.80
Hedge	do	Two series		80–100	1.12	.17	.65
Ward	do	do		35–55	2.57	.50	1.54
Skalkaho	do	Three series		30–38	2.25	.66	1.61
Surprise	do	One series	5.00	51.20			6.17
Supply	do	do	14.00	60.90			4.76
Allen, Hughes, et al.	do	do	1.25	8.32			17.30
Fowler and Sistah	do	do	3.00	7.23			7.46
Union	do	do	6.00	36.49			1.38
Nevada:							
Big Five	Lovelock Valley	Four series	1.00		46.30	8.20	39.90
Dangberg	Carson Valley	Two series	1–3		13.90	9.40	11.70
Lame	Mason Valley	One series	.25				26.80
Oregon:							
Adams (old)	Klamath Co	do	6.00	16.99			1.71
Adams (new)	do	do	8.00	18.16			1.57
Ankeny	do	Two series	6.50	43.00	2.79	1.96	2.38
Mitchell	do	One series	1.50	3.93			13.52
Pilot Butte	Deschutes	do	16.75	88.80	6.82	1.40	2.00
Oregon Central	do	do	4.69	56.60	18.27	12.50	12.65
Maxwell	Umatilla Co	do	4.23	16.30	39.60	11.20	18.57
Irrigon	do	Three series	8.50	7.22	10.11	3.60	7.22
Utah:							
Bear River, Main Line.	Bear River	Eleven series	5.50	225–550	3.43	.45	2.22
Bear River, West Line.	do	Six series	16.50	97–290	1.04	.44	.72
Bear River, Corinne	do	Five series	26.50	75–177	1.13	.20	.40
East Jordan	Jordan	One series	9.50	42.46			1.77
Logan and Richmond.	Logan	Six series		82.10			2.28
Logan, Hyde Park, and Smithfield.	do	Eight series		50.57			2.65
Washington:							
Kennewick	Yakima	Nine, miscellaneous.		70–160	3.00	1.23	1.96
Selah-Moxie	do	Four, miscellaneous.		30–50	2.40	.45	1.55
Wyoming: Canal No. 2	Laramie	Two series		40–90	1.00	.94	.97
Average							5.77

The most noticeable feature of this table is the wide variation in the rates of loss, even in the same canal, the table showing that a canal at one time loses ten times as much water as at another time, with no reason appearing in the report of the measurements. In a very few instances canals show gains. These have other canals or irrigated lands above them from which they receive seepage water the inflow of which can not be measured. These canals in fact lose water, but the loss is more than offset by incoming seepage. The low rates of loss are in every instance found in large canals, while the very high rates occur in every case in small canals. In almost no case do the measurements cover an entire canal, so that it is not possible to compute the total losses by seepage. The straight average of all the percentages given in the table is 5.77 per cent per mile, and it is probable that this represents fairly the average loss, taking into consideration canals of all sorts, sizes, and ages. Grouping the canals by stream valleys and averaging them again gives the following results, which may be considered representative of the localities named:

Seepage losses from canals by localities.

Stream.	Loss per mile.	Stream.	Loss per mile.
	Per cent.		*Per cent.*
Arizona: Salt River	1.07	Montana—Continued.	
California:		Gallatin Valley	1.36
Tule River	15.73	Bitterroot	[a]2.56
Santa Clara Valley	6.00	Nevada: Lovelocks, Canon, and Mason valleys	26.13
Tuolumne (Modesto)	.65	Oregon:	
Cache Creek	5.55	Klamath	[a]1.89
Sacramento (Central)	3.40	Deschutes	7.33
Imperial laterals	2.85	Umatilla County	12.90
Idaho:		Utah:	
Twin Falls, main line	1.17	Bear River, main line	2.22
Twin Falls, branches	1.68	Bear River, branches	.56
Colorado:		Jordan Valley	1.77
Grand—has canal above	+.13	Logan Valley	2.47
Lake—has canal above	.49	Washington: Yakima	1.76
Montana:		Wyoming: Laramie	.97
Yellowstone	1.23		

[a] Excluding two small ditches showing abnormal losses.

The conditions affecting seepage are so numerous that few generalizations can be made. Other things being equal, canals in sandy soil lose more water than those in clay, new canals lose more than old, small canals lose a higher percentage of their flow than large canals, canals which have been unused during the winter lose more water in spring than later in the season, due to the opening up of the soil by freezing and thawing, yet measurements contradictory of every one of these statements occur so frequently as to throw doubt upon their truth.

The measurements given have a public value in calling attention to the magnitude of the losses and enabling engineers planning works to make an approximate estimate of probable losses, but their greatest value is to the owners of the canals measured, since they point out the

sections where losses are largest, showing where work should be done to check them, and show the magnitude of the losses, which can be used as a basis for estimating the expense which can be undertaken profitably to stop the losses.

CHECKING SEEPAGE LOSSES.

Where large losses occur in short sections of a channel, a common method of stopping them is by building timber flumes to carry the water over the leaky sections, or lining the channels with cement or concrete. Where the losses are distributed throughout long sections of earthen channels the problem is more difficult. It is evident that these losses can be prevented by carrying the water in pipes and very nearly stopped by lining canals with cement concrete or cement plaster, and as the magnitude of the losses is better appreciated and the value of water grows, an increasing part of the water supply for irrigation will be carried in this way. But at present these means are too expensive for most places and most crops. The real problem of reducing losses is to bring the cost within the limits allowed by the value of the water saved or to increase the net returns due to the saving by decreasing the cost still further. In southern California, where water is scarce and the value of products high, seepage losses have been almost eliminated by lining the main ditches with cement concrete or plaster and distributing the water to the fields in underground pipes, and other less expensive linings have been tried there and elsewhere.

To determine the effectiveness of these linings, this Office, in cooperation with the University of California, carried out a series of experiments [a] under direct charge of Prof. B. A. Etcheverry. Pits similar to canal sections were made and lined with the substances to be tested, while similar pits were left unlined for purposes of comparison. The following table shows the efficiencies of the various linings, expressed in percentages of saving of the loss from the unlined pits:

Effectiveness of ditch linings.

Description of lining.	Saving.	Experimental cost of lining per square foot.[b]	Actual cost of lining per square foot.[b]
	Per cent.	*Cents.*	*Cents.*
Cement concrete, 3 inches thick	86.6	8.30	7.50
Cement lime concrete, 3 inches thick	65.5	8.30	7.50
Cement mortar	63.3	3.88	3.25–3.50
Heavy oil, 3⅔ gallons per square yard	50.4	1.20	1.20
Clay puddle, 3.5 inches thick	47.8	3.90	1.20
Heavy oil, 3 gallons per square yard	38.0	1.00	1.00
Heavy oil, 2⅓ gallons per square yard	27.3	.77	.77
Thin oil, 2.5 gallons per square yard	7.3	1.00	.80
Earth (no lining)	.0		

[a] See California Sta. Bul. 188.

[b] Excluding the preparation of the ditch.

While there is no doubt that cement concrete is the most effective as regards seepage, it is also the most expensive, the cost being more than six times that of the heavy oil lining ($3\frac{2}{3}$ gallons per square yard), which saved 50.4 per cent of the water which would have been lost were the ditch not lined, while the saving with the concrete ditch is 86.6 per cent, or only one and three-fourths times as large. Where water is very valuable there is no doubt that the concrete ditch is more permanent and economical. But where the water is not so scarce, and a little waste will do no damage, the expense of lining the ditch with oil may be justified, while a more expensive lining would be impracticable. The durability of the oil linings has not been thoroughly tested, and it may be that more extended experience will show them to be less valuable than these experiments would indicate.

A large number of canals in southern California have been lined with cement concrete, cement plaster, and masonry, and various combinations of these. These are described, with data as to cost, in the bulletin containing the results of the experiments just discussed.

The cost data given are summarized below:

Description, nature, and cost per square foot of canal linings used in California.

Description of lining.	Cost.
	Cents.
Rocks laid in hydraulic lime mortar, 8 inches thick, plastered with cement mortar, 1 to 3 mixture (labor $1.25 per day; lime, $1 per barrel)	6.5
Cobbles laid in lime mortar, 1 foot thick, faced with cement, one-half inch thick, 1 to 3 mixture	13.0
Cobbles laid in cement mortar, 6 inches thick (labor $1.75 per day; masons, $3.50 per day; cement, $3 per barrel)	13.0
Cement concrete, 4 inches thick, 1 part cement to 7 parts coarse gravel (labor, $2 per day; foreman, $3 per day; cement, $2.85 per barrel; gravel, 60 cents per cubic yard)	10.5
Same, 3 inches thick	8.0
Cement mortar, three-fourths inch thick, including preparation of banks (1 to 4 mixture)	4.0
Cement plaster, one-fourth to one-half inch thick	2.0
Cement plaster, 1 inch thick, 1 to 4 mixture on bottom and 1 to 6 on sides	2.8

It is the common belief that in climates where the ground freezes to a considerable depth in the winter plaster or concrete linings in earthen channels are not practicable, because the heaving of the ground will break the linings; but Doctor Mead reports the practice in Italy of covering the concrete lining with earth or sand to protect it from freezing.[a] The channel is cut larger than the required cross section, lined, and the earth protection placed over the lining.

A lined canal can be given a much steeper grade than an unlined canal, because it is not necessary to guard against erosion, and where the fall is available the decrease in the size of the channel required to carry a given quantity of water and the decrease in the quantity which must be diverted to supply a given quantity at the place of use will

[a] U. S. Dept. Agr., Office Expt. Stas. Bul. 144, p. 36.

in many cases reduce the cost of excavation sufficiently to meet a large part of the cost of lining. If to this be added the decreased danger of breaks in canal banks, the doing away with injury to lowlands by water seeping from canals, the stopping of the growth of the aquatic vegetation in canals, and the stopping of the deposit of silt by the increased velocity of the water, it is believed that this lining of canals will prove profitable in many places where it has not hitherto been considered. It may mean a slightly increased first cost, but a greatly decreased cost of maintenance. However, the great losses are from canals already built without linings, so that what has been said regarding decreased cost of excavation will not apply.

With these existing ditches the problem is to check or stop the losses at a cost which can be borne by the crops grown under them, rather than rebuild the canals, although in some extreme cases rebuilding might be the most economical solution.

Almost all water, and especially that from streams, carries some silt, and this silt deposited in canals is the most effective check upon seepage losses which has been found, except cement lining. But in order that silt may be deposited the velocity of the water must be low. Many canals, especially the older ones, are built on such heavy grades that the silt is not deposited and the canals improve little with age. The remedy for this is the putting in of checks and drops, which will check the velocity and allow the settlement of the silt. But too low a velocity will cause the deposit of too much silt, encourage the growth of vegetation, which catches more silt, thus aggravating the trouble and necessitating the cleaning of the canal.

When the water does not carry much silt the same effect has been secured by dumping pulverized clay into the water and keeping it stirred up in such a way that it will be carried down the canal and deposited along the bottom and sides. This has proved quite effective, but where the ground freezes hard in the winter the opening up of the soil by the frost is apt to destroy the effectiveness of the clay and make a new coating necessary.

Another experiment which has been tried with some success is driving sheep or hogs through the canal when it has some water in it, thus puddling the bottom.

Seepage losses from the Maxwell Ditch in Umatilla County, Oreg., were checked by putting in the bottom of the ditch a mixture of manure, sand, and gravel. In the sections where the loss was greatest the bottom of the channel was excavated to a depth of about a foot, and this space was filled with the mixture, which was thoroughly puddled with water. Upon this blanket the silt which had been removed from the channel was deposited, and also puddled under water by driving the teams back and forth over it. The beneficial

effects were very noticeable, for where water had come through the banks in small streams they became dry.[a]

Measurements of the losses from the Irrigon Canal, in Umatilla County, Oreg., and an account of experiments made to stop these losses are reported by Mr. Stover.[b]

Two series of measurements made in July and in August, 1905, showed losses from a section of the canal about 9 miles long averaging 8.8 per cent of the volume taken in at the head in each mile of ditch, when the canal carried at the head from 15 to 20 cubic feet of water per second.

The season previous much work had been done on the canal channel in order to make it impervious. At that time it was thought that by plowing up the bottom of the channel and thoroughly incorporating with the sand such silt as had collected a more impervious layer would be secured, and to this end a great deal of work was done both in the way of plowing and harrowing the channel and also in the way of packing it by means of a corrugated roller. After this work had been done it seemed as though the channel lost as much water as it had before being treated, and at the beginning of the season of 1905 it was decided to abandon this practice and simply leave the silt to collect as quickly as possible and form a compact layer on top of the sand. The result was that wherever the velocity of the water slowed down a heavy deposit of silt occurred and considerable bodies of silt were formed in the channel. As soon as sufficient silt had collected to form a rooting place for aquatic plants a growth of moss sprang up, which also aided the deposit of silt. Silt bars formed wherever the water formed an eddy or wherever the velocity was decreased, and these bars at the time the first series of measurements was made had increased in size to such an extent that they formed a serious obstruction in the channel, backing the water up upon the banks and increasing by a considerable amount the wetted perimeter. This increase in the wetted section, of course, only tended to increase the amount of seepage, and although the canal channel appeared to be full of water, it failed to deliver any considerable amount into the distributing laterals at the end of the system. Soon after the first series of measurements was made a campaign was begun to rid the channel of these obstructions. It was thought best not to get rid of this silt entirely, but rather to stir it up and permit it to pass on down the channel and deposit more uniformly in other sections. The bars were harrowed down and the silt was kept thoroughly stirred up in the water and allowed to flow on down the canal. After the worst bars

[a] A. P. Stover, Irrigation Practice in Oregon. U. S. Dept. Agr., Office of Expt. Stas. Cir. 67, p. 23.

[b] Ibid, p. 26.

had been reduced a spring-tooth harrow and also a disk harrow were used to further assist in evenly distributing the silt. This treatment, however, seemed to stir up the bottom of the channel much in the same way as did the treatment it received in the previous year. At this time the second series of seepage measurements was made, and the results indicate that the loss was not greatly different from what it had been before the silt bars had been reduced. The wetted perimeter had been lessened, but the wetted surface had been stirred up and made more porous. With a view to producing the same beneficial result without this stirring factor it was suggested that a specially devised implement might be used. This implement consisted, essentially, of a long anchor chain, the ends of which were attached to a beam placed across the running gear of a wagon. This was drawn up and down the canal in such a manner that the loop formed by the chain covered the entire wetted perimeter of the channel and not only stirred up the silt and prevented the moss growing, but had a rolling effect and thereby compressed the surface of the channel. This device was used continuously for about three weeks, with the result that water was delivered to the foot of the farthermost lateral with a slightly decreased amount entering the headgate—a thing which would have been quite impossible at the time the first series was made. Measurements showed that by this treatment the loss was reduced to 3.6 per cent per mile. The chain was at first suggested as a possible means for preventing the excessive growth of moss, but after having been used for this purpose it was found that it not only prevented the growth of moss, but also served to puddle the channel. At various points along the line, where loss through the bank had been visible, the leakage was stopped, and places below the canal, which had been filled with standing water rapidly dried up, showing that the channel had been made quite impervious. This implement as first constructed was made of the hind running gears of a wagon, across which was placed a long beam and at the ends of the beam the ends of the heavy chain were fastened so that when the running gears were drawn forward the chain dragged in a long loop and had a rolling effect, which not only tore out the roots of the moss but also rolled and puddled the surface. Encouraged by the beneficial results obtained with this crude implement, a longer and heavier chain was secured and used with good effect.

Seepage losses have been the cause of much contention between canal owners and the persons using water under them. Most water-right contracts provide for the delivery of a certain quantity of water to each user, but contain a provision that in case of scarcity whatever water the canal supplies shall be prorated among all the holders of rights. In practice this places the burden of seepage losses on the water users rather than on the company, although the com-

pany is responsible for the care of the canal. Such losses have also caused some contention between canal owners and the public officials charged with distributing water from streams in States where rights are limited to a fixed quantity per acre served, as in Wyoming, Nebraska, and Nevada. The companies contend that they should be allowed enough water to deliver the legal quantity at the point of use, while the officials contend that the quantity should be measured at the headgate, placing the burden of preventing loss on the canal owners. The latter system would undoubtedly have a tendency to check losses, while the other would place a premium on poor construction and careless maintenance.

MOST ECONOMICAL USE OF WATER.

Studies of the most economical use of water have taken two forms: Field and plat experiments to determine the relation between the quantity of water used and crop returns, and tank and field experiments to determine the losses of water by evaporation and percolation from soils to which water is applied by different methods and which receive different degrees of cultivation after irrigation. The work of both kinds has been done principally in cooperation with the State stations. In neither line has the work been continued long enough to justify final conclusions, but the experiments promise very valuable and practical results.

Plat and field experiments to determine the relations between the quantity of water used and crop returns have been carried farther in Utah than elsewhere. At the Utah experiment station plat experiments have continued through several years, and a very large amount of data secured, which is now being digested and put in shape for publication. Field experiments were carried on at several places in the State, in cooperation with farmers. The general plan is the same for all the experiments. The cooperating farmer waters one plat according to his own judgment, and gives to some other similar plats more water than he uses on his own plat and to others less. Careful records are kept showing dates of irrigation, quantities of water applied, rainfall, and yields. Each experiment becomes a demonstration to the farmer and his neighbors of the best practice in that locality. In 1905 six such experiments were carried to completion. In three of these the farmer secured the largest yields per acre, and in three larger yields were secured from other plats, but in each of these three instances the larger yields came from plats receiving more water than the farmer's plats, showing that, so far as these farmers are concerned at least, the farmers of Utah are not using so much water as to injure their crops. In two instances the largest yields came from the plats receiving the most water, and in two the smallest

yields came from the plats receiving the least water. In only one instance did the farmer's plat produce the largest yield per unit of water used, the maximum yield per unit of water coming from the plats receiving the least water in four out of the six cases. Whether the largest return per acre or the largest return per unit of water used constitutes the best use of water depends upon the relative value and scarcity of land and water and upon other factors, such as expense of cultivating increased areas, etc., but these experiments serve to point out to farmers the facts regarding the returns received from the use of water in such a way that they can determine for themselves the most economical use under their own conditions. As more data of this character are accumulated, it will be possible to draw general conclusions not justified by the results so far secured.

LOSSES BY EVAPORATION AND PERCOLATION.

It is common knowledge that a large part of the water applied to land is evaporated while being applied and from the wet soil in the days following irrigation, and that this loss can be checked to a certain extent by applying the water in such a way that the surface soil does not become wet, and by cultivation as soon as the soil is dry enough to create and maintain a dust mulch. But there has been no exact knowledge as to the extent of the losses or the efficiency of the common methods of checking these losses. To secure some quantitative measure of the losses and the effect of preventives, tank experiments were begun in 1904 by this Office, working in cooperation with the State of California.

Tanks arranged for convenient weighing were filled with soil, and measured quantities of water were applied in furrows of different depths, and the wet soil was protected by mulches of different thicknesses, imitating field conditions as nearly as possible. The results of these experiments conducted by Dr. Samuel Fortier were published as a bulletin of this Office,[a] but it was not deemed advisable to place too much dependence upon a single series of experiments. During the season of 1908 equipment for similar experiments was installed at Sunnyside, Wash.; Bozeman, Mont.; Reno, Nev.; Williston, N. Dak.; and Agricultural College, N. Mex., where like experiments were carried on simultaneously. The California experiments have been summarized as follows:

The first experiment had for its object the determination of the losses by evaporation from the soil from the time water is applied until the soil is fit to cultivate, and a comparison of the losses from cultivated and uncultivated soils. The tanks received sufficient water to cover them to a depth of about 12 inches. At the end of five days

[a] U. S. Dept. Agr., Office Expt. Stas. Bul. 177.

they had lost 15 per cent of this water. One set of tanks was then cultivated by stirring to a depth of 6 inches, while the others were left uncultivated, and after six days the weighings showed that the uncultivated tanks had lost an additional 11.3 per cent of the moisture originally applied, and the cultivated tanks had lost during the same time 5.7 per cent of the original amount, a difference of 5.6 per cent of the amount applied in favor of the cultivation, or about 50 per cent of the loss from the uncultivated tanks during the six days.

A repetition of this experiment with smaller quantities of water showed losses from all tanks of 10.5 per cent of the amount applied in the first three days after the water was applied, and during the next three days a loss of 3.6 per cent from the uncultivated tanks, and only 1.2 per cent from the cultivated tanks. That is, two-thirds of the loss during the second period of three days was saved by the cultivation.

Experiments to determine the effectiveness of mulches of different depths showed losses in fourteen days of 22.5 per cent, with no mulch; 7 per cent with a 4-inch mulch; 2.5 per cent with an 8-inch mulch; and 1.5 per cent with a 10-inch mulch, showing that the 10-inch mulch almost stops evaporation. This experiment did not imitate field conditions very closely, as the dry mulches were placed over the soil after the water had been applied, which could not be done in the field.

The next experiment imitated field conditions much more closely. In California a few years ago the common practice was to apply water to orchards in a large number of shallow furrows made between the rows. The present tendency is to decrease the number of furrows and increase their depth. This experiment was made to determine the advantages of the more recent practice. Water was applied to the surface and in furrows 3, 6, 9, and 12 inches deep. In a ten-day period the losses were, with water applied at the surface, 25 per cent of the quantity applied; with 3-inch furrows, 21 per cent; with 6-inch furrows, 17 per cent; with 9-inch furrows, 16 per cent; and with 12-inch furrows, 12 per cent. In other words, applying water in deep furrows prevented one-half the loss which occurred when water was applied on the surface.

These results apply, of course, almost solely to orchards, since with crops which cover the surface or with annual crops with shallow-root systems the water must be applied on or near the surface. The experiments show that in round numbers about one-fourth of the water applied to orchard soils is lost by evaporation in the first ten or fifteen days after irrigation when water is applied in such a way that the entire surface becomes wet, and this loss is decreased by half, or is about one-eighth of the amount applied, when it is applied in deep furrows, so that the surface soil does not become wet. While these results apply to orchards only, they illustrate the general rules

which should be followed as closely as possible—that is, avoid wetting the surface soil and cultivate the top soil as soon as possible after irrigation. The results of the experiments made in 1908 are not yet available, but they tend to confirm the results of the earlier experiments.

PERCOLATION.

Studies of the percolation of irrigation water were made in California by Dr. R. H. Loughridge, of the University of California, in conjunction with the evaporation experiments just discussed. These did not yield results so satisfactory as those from the tank experiments so far as giving definite measurements of losses. They were conducted in the field where accurate measurements are practically impossible, and where none of the conditions is under the control of the experimenters.[a] One method adopted for determining the rapidity and depth of percolation was the cutting of a trench across several furrows in which water was to be run, and noting the advance of the wet area on the face of this trench, the water flowing in the furrows being carried over the trench in wooden flumes. Another method was the taking of samples with a soil auger at the desired intervals. Observations were made in several orchards and in different parts of the same orchard, the depths of percolation differing very widely between the different points measured. It was found that in the light, open soil a large part of the water was lost by percolation beyond the reach of tree roots near the upper ends of the furrows, and that the part of the orchard below received insufficient water. Percolation downward was so rapid that water did not reach the tree rows by lateral percolation, leaving a large part of the roots in soil so dry as to be of little use to the trees. On the other hand, in an orchard where hardpan was near the surface, water spread rapidly sidewise, and very little went down. It rose to the surface, and was exposed to evaporation, increasing the loss from that cause. These experiments demonstrated the need of further study along this line, but the point most strikingly brought out is the necessity that each irrigator study the action of water in his own soil and adapt his methods to his own conditions.

From the foregoing discussion of losses of water it is apparent that not more than 50 per cent of the water diverted from streams reaches the lands for which it is intended, the balance being lost in transit. There are further large losses by evaporation from the soil and by percolation beyond the reach of plant roots. It is conservative, therefore, to state that not more than one-third of the water diverted from streams contributes to the growth of plants. It has been shown that a large part of the losses mentioned can be stopped. In many sections the point has already been reached where a more economical use of

[a] U. S. Dept. Agr., Office Expt. Stas. Bul. 203.

water is the only source of supply for increasing the area irrigated, and this condition is constantly becoming more common. As these conditions advance, the work of this Office in devising methods of checking losses will be increasingly valuable. As it is, this is the most promising field for expansion, since providing additional water supplies is constantly more expensive, while much of this saving can be accomplished not only without great expense, but with positive benefit to the lands now watered.

SUPPLYING PRACTICAL INFORMATION TO WATER USERS.

Investigation is of little value if the improvements worked out are not put into practice. From the beginning of our work efforts have been made to supply the information secured to water users. This is done by the preparation and distribution of practical bulletins, by personal advice by our agents in the field, and by assisting in the maintenance of demonstration farms. The last few years have been unparalleled in activity in the construction of irrigation works and the throwing open of new land to settlement. Most of the settlers are unfamiliar with irrigation, and just at this time the aiding of these settlers by instruction in the proper use of water is fully as important as studies and experiments to bring about improvements in practice in the regions already well developed.

PUMPING.

Soon after the irrigation investigations were begun Congress added to the work investigations into the use of power for irrigation. This work has been carried on for a number of years, including field studies of pumping plants of various kinds in actual use, and laboratory and other tests of pumps, engines, and windmills. Much of the value of the field studies lies in pointing out to the owners of the plants visited ways in which they can get larger service from their plants, but the data collected are of value in giving general statements of areas served, cost of plants, and cost of operation. These data are summarized in the following pages.

The tables bring together the results of all the tests of plants in which it is possible to compute the quantity of fuel used per unit of output. The unit of output used in the tables is the foot-acre-foot, because it is believed that this is the unit most easily interpreted by the farmer. Knowing the vertical distance from the water level in his well to the point of discharge, and the depth of water he wishes to apply to his land, he can compute the work to be done in terms of foot-acre-feet by multiplying together the lift in feet and the depth to which he wishes to cover his land, expressed in feet. By reference to the table he can find out how much gasoline is consumed in doing this work, under average field conditions. Knowing the price of gasoline in his own neighborhood, he can determine the fuel

cost of pumping the desired quantity of water. These tables are especially valuable from the fact that they present the results secured under ordinary field conditions rather than the claims of manufacturers or the possibilities under ideal conditions with expert operators.

The data are grouped according to the most common types of plants, as follows: Gasoline engines and centrifugal pumps; gasoline engines and deep-well pumps; steam engines and centrifugal pumps; steam engines and rotary pumps; electric motors and centrifugal pumps; electric motors and deep-well pumps; and air lifts. All the steam engines included used crude oil as fuel, and were located either in California or Texas.

Fuel cost of pumping with gasoline engines and centrifugal pumps.

Plant No.	Rated horsepower of engine.	Pump.		Discharge per minute.	Lift.	Cost of fuel per gallon.	Fuel used per foot-acre-foot.	Cost of fuel per foot-acre-foot.	Cost of plant.
		Size.	Kind.						
		Inches.		*Gallons.*	*Feet.*	*Cents.*	*Gallons.*	*Cents.*	
1	3	1.5	Horizontal	32	18.00	6.75	3.38	22.80	....
2	8	4.0	Vertical	69	33.40	6.75	1.85	12.50	....
3	11	4.0	Horizontal	112	30.00	7.00	1.47	10.30	$1,075
4	8	3.0	Vertical	69	53.80	5.50	1.54	8.50	....
5	5	3.0	Horizontal	208	19.40	7.00	1.03	7.20	1,050
6	7	3.0	Vertical	147	31.50	6.75	.70	4.70	1,800
7	11	3.0	do	76	77.50	5.50	1.13	6.70	2,000
8	11	4.0	do	147	44.40	5.50	.73	4.00	3,056
9	5	4.0	Horizontal	301	24.60	7.00	.54	3.80	700
10	11	3.0	Vertical	148	53.50	5.50	.80	4.40	1,200
11	10	3.0	Horizontal	165	49.50	7.00	.61	4.30	1,400
12	15	4.0	Vertical	224	43.50	5.25	.63	3.30	2,000
13	12	4.0	do	215	48.50	7.00	1.06	7.40	1,500
14	12	4.0	do	214	49.00	6.75	1.04	7.00	1,400
15	25	5.0	do	258	46.00	6.75	.96	6.50	....
16	11	5.0	Horizontal	361	33.50	6.75	.50	3.40	1,500
17	25	5.0	Vertical	241	53.00	5.50	.73	4.00	1,475
18	15	4.0	do	267	50.00	6.75	.50	3.40	....
19	25	5.0	do	393	45.20	5.25	.69	3.60	3,500
20	25	5.0	do	594	35.50	5.25	.97	5.10	....
21	24	5.0	do	459	49.50	7.00	.57	4.00	2,300
22	30	5.0	do	266	89.50	5.25	.63	3.30	....
23	25	4.0	Compound vertical	226	109.00	5.25	.40	2.10	....
24	24	5.0	Vertical	615	41.30	5.50	.45	2.50	3,800
25	22	5.0	do	446	58.50	5.25	.57	3.00	2,400
26	38	4.0	Compound vertical	153	171.50	6.75	.64	4.30	2,400
27	21	5.0	Vertical	359	73.20	7.00	.37	2.60	3,500
28	35	5.0	Compound vertical	216	122.00	7.00	.77	5.40	3,100
29	18	5.0	Vertical	590	45.70	5.50	.46	2.50	1,300
30	23	5.0	do	437	68.60	5.50	.33	1.80	2,000
31	25	5.0	do	635	47.70	5.25	.48	2.50	2,300
32	30	5.0	do	399	80.00	5.25	.42	2.20	3,500
33	24	5.0	do	531	60.70	5.25	.42	2.20	3,036
34	21	5.0	do	570	57.00	5.25	.31	1.60	1,893
35	30	5.0	do	472	72.00	5.25	.31	1.60	1,800
36	32	4.0	Compound vertical	371	96.00	6.00	.47	2.80	3,200
37	64	5.0	do	398	96.00	6.75	.75	5.10	....
38	25	6.0	Vertical	553	70.40	5.50	.38	2.10	2,295
39	32	5.0	do	568	69.00	5.50	.33	1.80	....
40	30	5.0	Compound vertical	392	105.50	5.25	.55	2.90	3,000
41	30	6.0	Vertical	608	68.00	5.50	.51	2.80	3,343
42	35	5.0	Compound vertical	369	113.00	5.50	.55	3.00	3,100
43	30	4.0	Vertical	680	62.00	6.75	.33	2.20	2,500
44	30	5.0	Compound vertical	484	93.50	5.25	.53	1.80	3,200
45	35	5.0	do	490	95.00	5.50	.40	2.20	4,000
46	35	6.0	do	592	90.40	5.00	.44	2.20	3,000
47	35	....	....	975	69.00	12.00	.45	5.46	....
48	22	....	....	796	31.00	11.50	.43	4.93	....
49	20	....	....	338	89.00	11.30	.71	8.17	....
50	25	....	....	427	80.00	10.50	.49	5.16	....
51	19	....	....	229	87.00	5.00	75	3.76	....

Fuel cost of pumping with gasoline engines and centrifugal pumps—Continued.

Plant No.	Rated horsepower of engine.	Pumps.		Discharge per minute.	Lift.	Cost of fuel per gallon.	Fuel used per foot-acre-foot.	Cost of fuel per foot-acre-foot.	Cost of plant.
		Size.	Kind.						
		Inches.		*Gallons.*	*Feet.*	*Cents.*	*Gallons.*	*Cents.*	
52	12	6.0	....	433	33.10	13.00	.54	7.00	....
53	12	5.0	Horizontal	354	27.00	12.25	.88	9.70	$1,400
54	6	3.0	do	225	20.50	15.00	.73	10.95	375
55	9	5.0	do	699	21.00	15.00	.65	9.78	775
56	12	5.0	do	679	23.34	12.80	.43	5.55	900
57	15	6.0	do	698	22.00	11.80	.59	7.50	1,000
58	15	5.0	do	1,124	16.00	12.25	.74	9.00	1,000
59	10	4.0	do	355	22.00	11.80	.61	7.20	750
60	15	5.0	do	372	20.00	11.25	.69	7.76	1,250
61	10	4.0	do	390	22.00	11.25	.48	5.40	....
62	15	6.0	Vertical	802	24.00	12.25	.52	6.37	1,200
63	12	6.0	Horizontal	376	24.50	11.80	.72	8.50	....
64	12	6.0	do	572	27.00	11.80	.79	9.32	....
65	6	2.5	do	122	24.75	11.80	.94	11.00	550
66	6	4.0	do	350	21.00	11.80	.55	6.49	550

Fuel cost of pumping with gasoline engines and deep-well pumps.

Plant No.	Horsepower of engine.	Pump.			Discharge per minute.	Cost of fuel per gallon.	Fuel used per foot-acre-foot.	Cost of fuel per foot-acre-foot.	Cost of plant.
		Diameter.	Stroke.	Lift.					
		Inches.	*Inches.*	*Feet.*	*Gallons.*	*Cents.*	*Gallons.*	*Cents.*	
1	2.00	3.50	9.00	20.00	13.00	7.00	[a] 4.80	33.50	$500
2	2.00	3.50	9.00	20.00	20.00	17.00	2.47	42.20	500
3	2.00	4.00	7.00	52.00	14.00	7.00	1.40	9.80	500
4	12.00	9.00	26.00	84.00	20.00	7.00	[a] 6.60	46.30	2,350
5	3.50	....	10.00	124.00	21.00	7.00	.51	3.60	....
6	5.00	7.00	18.00	42.00	83.00	5.00	.85	4.70	700
7	5.00	5.00	18.00	160.00	26.00	5.25	.55	2.90	900
8	8.00	6.00	21.00	165.00	31.00	7.00	1.49	10.40	1,500
9	12.00	5.00	30.00	160.00	40.00	7.00	.85	5.90	1,200
10	25.00	7.00	24.00	180.00	52.00	7.00	.79	5.50	1,500
11	12.00	8.00	16.00	115.00	94.00	5.50	.65	3.60	....
12	15.00	5.00	16.00	220.00	50.00	5.25	.40	2.10	2,500
13	10.00	....	16.00	138.00	85.00	6.75	.44	3.00	....
14	14.00	6.00	18.00	160.00	76.00	6.00	.37	2.20	2,000
15	20.00	10.00	24.00	65.00	207.00	5.50	1.10	5.80	2,650
16	12.00	7.00	19.00	145.00	94.00	5.50	.55	3.00	1,695
17	12.00	6.50	16.00	140.00	99.00	7.00	.59	4.10	1,500
18	12.00	8.00	24.00	140.00	114.00	7.00	.30	2.10	2,200
19	12.00	7.00	16.00	150.00	113.00	7.00	.70	5.00	....
20	14.00	7.00	24.00	110.00	183.00	5.25	.44	2.30	2,100
21	14.00	6.00	18.00	278.00	74.00	7.00	.30	2.20	3,500
22	22.00	8.00	36.00	145.00	147.00	5.50	.40	2.20	3,000
23	25.00	7.00	24.00	203.00	108.00	5.50	.40	2.20	3,000
24	23.00	7.00	24.00	190.00	143.00	....	....	....	3,200
25	34.00	9.00	36.00	134.00	213.00	7.00	.40	2.80	5,062
26	15.00	7.00	27.00	180.00	159.00	6.00	.30	1.90	1,555
27	25.00	10.00	32.00	83.00	379.00	6.25	.53	3.30	4,862
28	30.00	9.00	24.00	221.00	144.00	6.75	.38	2.60	....
29	14.00	9.00	24.00	135.00	248.00	6.75	.24	1.60	2,300
30	44.00	7.00	24.00	235.00	144.00	5.50	.34	1.90	6,000
31	30.00	9.00	36.00	125.00	275.00	5.25	.48	2.50	4,690
32	35.00	9.00	24.00	197.00	189.00	6.75	.33	2.20	3,500
33	34.00	9.00	30.00	210.00	224.00	7.00	.46	3.20	2,900
34	30.00	9.00	36.00	195.00	258.00	7.00	.37	2.60	3,000
35	50.00	9.00	30.00	205.00	249.00	6.75	.28	1.90	5,000
36	26.00	9.00	28.00	140.00	385.00	6.75	.27	1.80	5,000
37	35.00	9.00	30.00	215.00	252.00	7.00	.27	1.90	8,000
38	38.00	8.00	24.00	175.00	385.00	5.50	.27	1.50	....
39	75.00	....	....	200.00	868.00	9.50	.27	2.52	....
40	2.50	3.75	24.00	44.50	28.00	14.00	1.83	25.70	....
41	1.50	2.75	13.50	92.00	5.40	14.00	1.49	20.90	....
42	4.00	3.75	20.75	59.00	28.00	14.00	1.15	16.10	....
43	1.50	2.75	10.00	61.50	11.00	14.00	2.27	31.80	....
44	2.50	3.75	24.00	63.00	36.50	14.00	.93	13.00	....

[a] Omitted from average.

Cost of electricity for pumping with centrifugal pumps.

Plant No.	Rated horse-power of motor.	Pump. Size.	Pump. Type.	Pump. Discharge per minute.	Pump. Lift.	Cost of electricity per kilowatt hour.	Electricity per foot-acre-foot.	Cost of electricity per foot-acre-foot.	Cost of plant.
		Inch.		*Gallons.*	*Feet.*	*Cents.*	*Kilo. hrs.*	*Cents.*	
1	15	4.0	Vertical-single	320	62.0	2⅓	2.96	6.90	$1,150
2	20	4.0	do	270	80.0	3.00	2.53	7.60	1,600
3	20	5.0	do	342	66.0	2.00	3.10	6.20	....
4	15	4.0	do	251	95.0	2.50	3.28	8.20	....
5	20	5.0	do	396	66.0	2.00	3.60	7.20	....
6	20	3.5	Compound-vertical	216	124.5	2.25	3.78	8.50	1,200
7	20	5.0	Single-vertical	387	71.0	2.50	2.92	7.30	....
8	30	3.0	Compound-vertical	216	130.0	2⅓	2.48	5.80	4,000
9	30	5.0	do	285	108.5	2⅓	4.05	9.50	....
10	20	5.0	Single-vertical	448	73.2	2.50	2.16	5.40	2,200
11	30	5.0	do	564	60.3	2.50	2.64	6.60	1,600
12	40	5.0	Compound-vertical	622	94.3	2⅓	2.23	5.20	....
13	30	5.0	do	494	122.4	2.50	2.16	5.40	3,400
14	75	5.0	do	299	219.5	2.50	4.40	11.00	....
15	100	6.0	do	427	209.0	2.50	3.12	7.80	....
16	75	5.0	do	634	194.5	2⅓	2.36	5.50	....
17	100	6.0	do	818	189.0	2.50	1.88	4.70	6,000
18	50	....	....	388	150.0	....	2.48	....	....
19	50	....	....	478	121.0	....	2.42	....	....
20	10	....	....	426	34.0	....	2.54	....	....
21	10	....	....	103	82.0	....	4.02	....	....
22	50	....	....	763	63.0	....	2.32	....	....
23	50	....	....	1,123	63.0	....	1.92	....	....
24	7½	....	....	252	41.0	....	2.42	....	....
25	20	....	....	544	53.0	....	3.00	....	....
26	....	....	....	489	54.0	....	2.42	....	....
27	40	....	....	1,286	50.0	....	3.06	....	....

Cost of electricity for pumping with deep-well pumps.

Plant No.	Horse-power of motor.	Pump. Diameter.	Pump. Stroke.	Pump. Discharge per minute.	Pump. Lift.	Cost of electricity per kilowatt hour.	Electricity per foot-acre-foot.	Cost of electricity per foot-acre-foot.	Cost of plant.
		Inches.	*Inches.*	*Gallons.*	*Feet.*	*Cents.*	*Kilo. hours.*	*Cents.*	
1	10	7	24	184	65	2.50	2.60	6.50	....
2	10	7	24	194	63	2.50	2.80	7.00	$3,580
3	20	10	24	336	63	2.50	2.52	6.30	4.950
4	15	7	18	189	197	2⅓	1.46	3.40	....
5	20	10	28	260	145	2.00	2.35	4.70	....
6	20	10	28	259	150	2.00	2.25	4.50	....
7	20	8	18	274	150	2⅓	2.06	4.80	2,500
8	30	8	24	240	175	2.50	1.80	4.50	4,249
9	15	10	....	421	116	2⅓	1.63	3.80	....
10	30	7	24	270	222	2.00	1.65	3.30	6,000
11	30	10	24	334	197	2⅓	1.54	3.60	....
Average	....	....	....	....	....	....	2.06	....	....

Fuel cost of pumping with air lifts.

Plant No.	Horse-power of compressor.	Discharge per minute.	Lift.	Cost of fuel per gallon.	Fuel used per foot-acre-foot.	Cost of fuel per foot-acre-foot.	Cost of plant.
		Gallons.	*Feet.*	*Cents.*	*Gallons.*	*Cents.*	
1	....	208	65	5.50	[a] 0.47	2.60	$2,500
2	25	134	124	1.90	[b] 3.68	7.00	3,200
3	35	600	50	1.80	[b] 3.67	6.60	5,000
4	125	952	88	1.80	[b] 1.78	3.20	7,500
5	200	2,078	42	1.80	[b] 1.67	3.00	35,000
Average	....	....	....	....	2.70	....	....

[a] Gasoline, not included in average. [b] Oil.

Fuel cost of pumping with steam engines and centrifugal and rotary pumps.

CENTRIFUGAL PUMPS.

Plant No.	Horse-power of engine.	Type of engine.	Size of pump.	Type of pump.	Discharge per minute.	Lift.	Fuel.	Cost of fuel.	Fuel used per foot-acre-foot.	Cost of fuel per foot-acre-foot.	Cost of plant.
			Inches.		Gallons.	Feet.		Cents.	Gallons.	Cents.	
1	35	Automatic, simple, noncondensing.	6	Single vertical	611	59.20	California oil	1.19	2.52	3.00	
2	75	do	5	Compound vertical	1,004	164.00	do	1.78	3.48	6.20	
3	75	Corliss, simple, noncondensing.	6	do	800	213.40	do	1.92	1.19	2.20	$10,000
4	75				936	88.00	do	1.79	1.68	2.94	
5	75				1,653	55.00	do	1.79	1.17	2.12	
6	40				591	71.00	do	1.79	1.84	3.30	
8	671	Simple, condensing, Corliss	6-20	Horizontal	70,650	16.20	Texas oil	$\frac{5}{6}$	1.02	.85	
9	230	do	2-36		52,200	11.20	do	$\frac{5}{6}$	.90	.75	
10	122	Slide valve, noncondensing			27,720	4.70	do	$\frac{5}{6}$	2.18	1.82	
11	648	Simple, condensing, Corliss	4-18	Horizontal	41,940	30.20	do	$\frac{5}{6}$	.77	.64	
12	138	Simple, noncondensing, Corliss.	36	do	32,130	9.50	do	$\frac{5}{6}$	.84	.70	
13	504	Simple, condensing, Corliss	2-24	do	30,915	28.70	do	$\frac{5}{6}$	1.08	.90	
14	452	Tandem, compound, condensing, Corliss.			38,543	31.65	do	1.07	.39	.42	
15	122	Slide valve, noncondensing	20		13,053	15.40	do	$\frac{5}{6}$	1.78	1.48	
16	72	Simple, noncondensing	8	Vertical	972	14.20	do	1.25	a 12.35	15.45	
17	31	do	6	do	1,647	15.30	do	1.25	5.02	6.27	2,530
18	194	Triple expansion Marine	52		58,725	6.80	do	1.86	1.14	2.08	

ROTARY PUMPS.

Plant No.	Horse-power of engine.	Type of engine.	Size of pump.	Type of pump.	Discharge per minute.	Lift.	Fuel.	Cost of fuel.	Fuel used per foot-acre-foot.	Cost of fuel per foot-acre-foot.	Cost of plant.
1	157	Tandem, compound, condensing, Corliss.		Rotary	32,670	15.50	do	.56	.51 .51	b .26 c .28	
2	29	Simple, noncondensing, slide valve.		do	12,915	15.30	do	.95	3.52	3.34	
3	658	Tandem, compound, condensing, Corliss.		Cycloidal, rotary	68,805	31.62	do	1.90	.45	.86	

a Omitted from averages. b With heater. c Without heater.

The results given in detail in the foregoing tables are summarized below. The plants of each type are divided into groups to show the influence of the size of plant upon the fuel consumed per unit of work done. The average consumption of gasoline per foot-acre-foot as shown by the summary is substantially the same with centrifugal and deep-well pumps, but there were a number of very small engines running deep-well pumps, which brought up the average. For engines of the same size the consumption of fuel with deep-well pumps is noticeably lower. The electricity used per foot-acre-foot also is noticeably lower with deep-well than with centrifugal pumps. With steam engines the largest fuel consumption is with air lifts, next largest with centrifugal pumps, and least with rotary pumps. The tests did not include steam engines running deep-well pumps.

Summary of data showing fuel consumption.

Type of plant.	Number of plants.	Fuel per foot-acre-foot.		
		Maximum.	Minimum.	Average.
		Gallons.	*Gallons.*	*Gallons.*
Gasoline engines and centrifugal pumps	66	3.38	0.31	0.70
Under 10 horsepower	10	3.38	.54	1.20
From 10 to 20 horsepower, inclusive	24	1.47	.43	.72
Over 20 horsepower	32	.96	.31	.52
Gasoline engines with deep-well pumps	41	2.47	.24	.69
Under 10 horsepower	11	2.47	.51	1.36
From 10 to 20 horsepower, inclusive	14	1.10	.24	.52
Over 20 horsepower	16	.79	.27	.39
		Kw. hours.	*Kw. hours.*	*Kw. hrs.*
Electric motors and centrifugal pumps	27	4.05	1.88	2.80
Under 10 horsepower	1			2.42
From 10 to 20 horsepower, inclusive	12	4.02	2.16	3.03
Over 20 horsepower	14	4.05	1.88	2.68
Electric motors and deep-well pumps	11	2.80	1.46	2.06
Under 10 horsepower				
From 10 to 20 horsepower, inclusive	8	2.80	1.46	2.21
Over 20 horsepower	3	1.80	1.54	1.66
		Gallons.	*Gallons.*	*Gallons.*
Steam engines and centrifugal pumps	16	5.02	0.39	1.69
Steam engines and rotary pumps	3	3.52	.45	1.49
Steam engines and air lifts	4	3.68	1.67	2.70

EFFICIENCY OF ENGINES, MOTORS, AND PUMPS.

Only a part of the tests supplied data for computing the efficiencies of the plants. The tests which give such data are summarized in the table following. The efficiencies given are the ratios between the indicated horsepower and the useful work done. Only in the case of the centrifugal pumps are enough plants included to give these averages any great value. There are enough of these so that they may be considered representative, and the averages show the relative efficiencies of the three types of motor included to be about what would be expected. The steam-engine plants show 44.6 per cent efficiency, electric-motor plants 41 per cent, and gasoline-engine plants 35.4 per cent.

Efficiencies of pumping plants of different types.

Type of plant.	Number of plants.	Efficiency.		
		Maximum.	Minimum.	Average.
		Per cent.	*Per cent.*	*Per cent.*
Centrifugal pumps with gasoline engines	15	49	20	35.4
Centrifugal pumps with electric motors	18	55	17	41.0
Centrifugal pumps with steam engines	22	70	5	44.6
Deep-well pumps with gasoline engines	3	52	33	45.0
Deep-well pumps with electric motors	4	53	37	45.0
Rotary pumps with steam engines	3	83	30	65.0
Rotary pumps with electric motors	2	54	49	52.0
Screw pump with electric motor	1			30.0

It is often desirable to know the relation between the rated horsepower of engines and the output of the pumps operated. This information contained in the reports of tests is summarized below, the plants being grouped according to type and size. The gasoline engines included with both centrifugal and deep-well pumps were delivering about one-fourth of their rated capacity, while the electric motors were delivering 31 per cent with centrifugal pumps and 47 per cent with deep-well pumps. The difference between the performances of gasoline engines with centrifugal and deep-well pumps, shown in other summaries, does not appear here. Stated differently, in ordinary field practice, rated capacities of gasoline engines are about four times the useful work done, computed from the weight of the water lifted and the measured lift, and the rated capacities of the electric motors used for operating pumps are about three times the work done, computed in the same way. This takes no account of friction losses in pipes, or of losses in the pump, engine, and transmission.

Ratio between rated horsepower of engine or motor and useful work done.

Type of plant.	Number of plants.	Ratio.		
		Maximum.	Minimum.	Average.
		Per cent.	*Per cent.*	*Per cent.*
Gasoline engines and centrifugal pumps	66	48.5	4.8	25.5
Under 10 horsepower	10	41.0	4.8	20.2
From 10 to 20 horsepower, inclusive	24	38.0	7.6	22.7
Over 20 horsepower	32	48.5	12.0	28.6
Gasoline engines with deep-well pumps	44	60.0	3.3	25.4
Under 10 horsepower	12	23.2	3.3	12.9
From 10 to 20 horsepower, inclusive	15	60.0	3.5	29.0
Over 20 horsepower	17	57.0	9.5	31.0
Electric motors with centrifugal pumps	24	41.5	17.0	30.8
Under 10 horsepower	1			35.0
From 10 to 20 horsepower, inclusive	9	41.5	21.3	32.7
Over 20 horsepower	14	41.5	17.0	29.2
Electric motors with deep-well pumps	11	82.0	30.2	47.0
Under 10 horsepower	0			
From 10 to 20 horsepower, inclusive	8	82.0	30.2	47.0
Over 20 horsepower	3	55.0	35.4	47.0

WINDMILLS.

The windmill is widely used as a source of power for pumping water for irrigation, especially on the plains east of the Rocky Mountains. During the last few years settlement in that section has been very rapid, most of the settlers depending on farming without irrigation. From the beginning of this activity in settling the semi-arid plains this Office has been urging the desirability, in fact the necessity, of irrigating small areas in connection with the farming of larger areas without irrigation, in order that the settler shall not be entirely without means of maintaining himself and family and his work animals in dry seasons, and may have fruit and vegetables in every season. For the greater part of this area water from streams is not available, but must be secured from underground sources by means of pumps or by storing storm waters. In order to be able to supply reliable information as to the possibilities of securing water for the irrigation of small areas by pumping, experiments with windmills have been carried on for several years at Cheyenne, Wyo., and data as to the cost and service of windmill pumping plants already in use have been collected. These data are summarized below. The data include the sizes of mills, the areas served, the cost of pumping plants and reservoirs, and annual cost of repairs, renewals, and oil. It is probable that the sizes are correctly given, and that the areas served and first costs of plants are approximately correct. The statements as to costs of reservoirs are probably no more than rough estimates of the cash outlay, not including anything for the labor of the farmer and his teams, although some may include these items. The annual costs are probably rough estimates and include little else than oil. Notwithstanding the uncertainty as to the accuracy of the data given, it is considered of sufficient value to justify its publication. It should be remembered that the performance of a windmill depends very largely on local wind conditions and the height the water must be lifted, and the fact that a 10-foot mill will supply water for nearly 3 acres in the Arkansas Valley in western Kansas where the lift is from 10 to 20 feet, as shown by the summary, does not indicate that it will do the same in eastern Colorado where the lift is more than 50 feet, and the average area served is but 1.8 acres.

Cost of pumping with windmills.

ARKANSAS AND PLATTE VALLEYS IN KANSAS AND NEBRASKA.

Number of plants.	Size of mills.	Average area served.	Average first cost.			Average annual cost.		Lift.
			Pumping plant.	Reservoir.	Total per acre served.	Per plant.	Per acre served.	
		Acres.						*Feet.*
4	6-foot	0.95	$65.50	$30.00	$100.00	$0.50	$0.53	[a] 10–20
13	8-foot	1.60	70.00	14.50	52.81	1.90	1.20	
9	10-foot	2.94	98.40	27.90	42.96	1.84	.62	
16	12-foot	5.20	174.60	74.07	47.82	5.07	.98	
1	16-foot	10.00	250.00	100.00	35.00	3.00	.30	
20	More than 1 mill				36.64		1.25	
	Straight average				52.54		.81	

EASTERN COLORADO.

Number of plants.	Size of mills.	Average area served.	Pumping plant.	Reservoir.	Total per acre served.	Per plant.	Per acre served.	Lift.
18	8-foot	0.7	$102.00		$147.00	$6.00	$8.57	24
12	10-foot	1.8	198.00		110.00	4.70	2.61	54
9	12-foot	2.4	195.00		80.00	8.00	3.33	56
8	14-foot	3.8	265.00		70.00	14.00	3.70	82
2	16-foot	3.6	188.00		52.00	17.50	4.82	40
	Straight average				92.00		4.61	51

[a] Estimated.

The average cost of the plants, including reservoirs, in the Arkansas and Platte valleys, where the lifts run from 10 to 20 feet, per acre served is $52.54, and the average in eastern Colorado, where the average lift is 51 feet, is $92 per acre served. While the cost is high as compared with water supplied by canals, the water is used principally for crops of high acreage value, such as fruit and vegetables, and the water has an added value because of the insurance feature, in adding an element of safety to dry farming, which is a precarious industry at best.

The technical studies and experiments with windmills at Cheyenne have included the keeping of records of wind velocities and the work done by the mills under all wind conditions; brake tests to determine the power developed by the mills; tests of automatic-stroke regulators; tests of "double-power mills" having two wind wheels; careful records of the first cost; and all expenses of maintenance, repairs, and operation in both labor and money. The report of these tests is not complete, but the following statement is taken from a preliminary report prepared by P. E. Fuller, who conducted the experiments:

A careful record was kept of the repairs and labor required to maintain the mills in proper working condition, and is here given. It was expected at the outset that if the windmill was occasionally inspected and oiled that was all that would be required, but it was found that a thorough and systematic examination of the boxes, nuts, and bolts and of all moving parts, together with an oiling of the mill, was absolutely necessary each morning, and the expediency of such a plan was shown by the lower repair charges after its inaugura-

tion. To effect this care it became the duty of a station man to devote the necessary time to each mill every morning, and it was found that it required an average of two hours to the 6 mills each day, not including the time devoted to repairs which were of a serious nature. These are charged separately in the following table.

So as to obtain the actual cost per acre-foot of water pumped by windmills the total quantity of water pumped during the season of 1908 is given, though during the former season all of the mills were not installed early enough to be of great value to the land irrigated.

Table showing costs of operation of mills at Cheyenne Station.

Mill No.	Cost.			Annual cost.		Equivalent cost per acre-foot.	Initial cost of plant, including wells.	Equivalent cost horse-power per hour.
	Repairing parts.	Maintaining mills at 6 cents per day.	Labor on repairs at $2 per 10-hour day.	Interest on entire plant at 8 per cent.	Total cost of operation of mill plant.			
1	$6.50	$3.60	$1.50	$22.16	$33.76	$16.08	$277	$0.22
2	5.20	3.60	5.60	18.96	33.36	19.28	237	.27
3	5.05	3.96	.80	19.76	29.57	16.24	247	.22
4	42.84	2.13	15.40	17.20	77.57	59.21	215	.82
5	1.50	3.36	6.00	18.08	28.94	11.35	226	.17
6	55.05	3.60	10.40	20.16	89.21	(a)	252	....

[a] Out of service.

Table showing character and performance of mills at Cheyenne Station.

Mill No.	Description of mill.	Size of pump cylinder.	Total work done.	Average horse-power per hour.	Number of hours mill operated.	Water pumped.	Water pumped.	Total of wind.	Rate of wind per hour.
			H. P. hours.			*Cubic feet.*	*Acre-feet.*	*Miles.*	*Miles.*
1	12-foot steel, back geared.	6-inch cylinder, 12-inch stroke.	150.34	0.105	1,432.25	91,598	2.10	18,408.00	12.86
2	12-foot steel, back geared.	6-inch diameter, 10-inch stroke.	124.03	.087	1,418.25	75,567	1.73	19,584.75	13.81
3	12-foot steel, back geared.	5-inch cylinder, 10-inch stroke.	130.48	.083	1,574.25	79,492	1.82	21,561.50	13.69
4	14-foot steel, back geared.	6-inch diameter, 12-inch stroke.	94.08	.111	843.75	57,315	1.31	11,671.00	13.83
5	16-foot wood, direct stroke.	6-inch cylinder, 8-inch stroke.	165.68	.123	1,342.50	110,939	2.55	16,111.50	12.01
6	14-foot double steel, forward gear.	8 inch by 10 inch twin cylinder.	(a)	....	....	....	....	....	....

[a] Not in service.

In justice to the various mills it is right to state that certain of the repairs were due to unusual accidents, such as Mill No. 4. A large part of the repair charge was incurred by an accident to the mill head, which became bound on one of the tower legs and could not cut itself out of the wind, with the result that the tail vane was so badly damaged as to require a new one. The original cause of the accident, however, was due to an inherent fault in the construction of the mill. This mill made several strokes during a cold night, which filled the discharge with water and, after freezing, the pump head or bonnet cracked and a new one was required.

The charge of $55.05 for repairs upon Mill No. 6 was for a new wheel to this mill; $22.05 covered freight charges, while the balance is estimated to be due to the fact that no charge was made for the repairs, as the mill had been loaned to the station for experimental work. For this reason the initial cost of the plant is assumed to be that of a plant in which the mill was purchased outright. The cause of the accident to this mill was unaccounted for, though the wind was blowing, as shown by the anemometer, at a rate of 72 miles per hour.

It is not the purpose of this discussion to attempt to compare one mill with another, but to determine, from the performance of a number of mills in which a record of cost is kept, the average cost of repairs when used for irrigation purposes. Referring to the table, it will be seen that the lowest total cost per acre-foot for water thus pumped against a 52-foot head is $11.35. This seems excessive, but it must be borne in mind that this is the cost of including a fixed charge of interest upon the mill and plant at 8 per cent per annum, and is therefore not the cash outlay. Further, as stated, the charge includes unusual repair charges which were on some of the mills due to severe strains when attempt was made to operate the plant without additional air chambers, as described before. These expenses would not have obtained if proper provision had been made beforehand. It will be observed, too, that the mills were shut down during about two-fifths of the season on account of experiment work upon the reservoir and in irrigation. If the mills had operated during the whole of the irrigation season of five months, the total number of acre-feet would have been about doubled—considering possible shutdowns—the interest charge would have been no greater, and the labor on maintenance only would have been increased, so that cost per acre-foot would have been about $6 instead of $11.35. The head against which the mills operated was 52 feet, and this, too, would affect the cost per acre-foot, for if the head had been, say, 25 feet, the quantity would have been about doubled again, so that the charge per acre-foot would have been $3. Taking the lowest charge in the table as representative and reducing the cost per acre-foot to cost per acre-foot for each foot of head pumped against, it shows the total to be about 11.5 cents, and if we consider only the cash outlay, assuming that the interest will be taken care of in the enhanced value of the land during the first ten years, it would be about one-third that given above, or 4 cents per acre-foot of water pumped by windmills against each foot of head. This, considering first cost and fuel, is much cheaper than water can possibly be pumped by any other power, except possibly, under favorable conditions, with water power.

USE OF ALCOHOL AS A FUEL.

At the time of the removal of the tax on alcohol for use in the arts, the popular demand for information as to the availability of denatured alcohol as a fuel for internal-combustion engines and the possible effect of its use on the cost of pumping water for irrigation led to the carrying out of laboratory experiments in its use by this Office in the laboratories of Columbia University in New York. The reports of these experiments [a] give full details of the experiments and show the relative value of gasoline, kerosene, and alcohol as fuels.

[a] U. S. Dept. Agr., Office Expt. Stas. Bul. 191 and Farmers' Bul. 277.

The report states that small engines consumed about 1.8 times as much alcohol as gasoline to develop a given amount of power. In other words, alcohol must sell for about 55 per cent as much as gasoline in order to produce power at the same cost. The most important conclusions reached are quoted below:

Any engine on the American market to-day, operating with gasoline or kerosene, can operate with alcohol fuel without any structural change whatever with proper manipulation.

Alcohol contains approximately 0.6 of the heating value of gasoline, by weight, and in the Department's experiments a small engine required 1.8 times as much alcohol as gasoline per horsepower hour.

An engine designed for gasoline or kerosene can, without any material alterations to adapt it to alcohol, give slightly more power (about 10 per cent) than when operated with gasoline or kerosene, but this increase is at the expense of greater consumption of fuel. By alterations designed to adapt the engine to new fuel this excess of power may be increased to about 20 per cent.

Because of the increased output without corresponding increase in size, alcohol engines should sell for less per horsepower than gasoline or kerosene engines of the same class.

It requires no more skill to operate an alcohol engine than one intended for gasoline or kerosene.

There seems to be no tendency for the interior of an alcohol engine to become sooty, as is the case with gasoline and kerosene.

The fact that the exhaust from the alcohol engine is not as hot as that from gasoline and kerosene engines seems to indicate that there will be less danger from fire, less offense in a room traversed by the exhaust pipe, and less possibility of burning the lubricating oil. This latter point is also borne out by the fact that the exhaust shows less smokiness.

In most localities it is unlikely that alcohol power will be cheaper or as cheap as gasoline power for some time to come.

IRRIGATION IN THE SEMIARID REGION.

The necessity for the irrigation of small areas in connection with dry farming on the semiarid plains has been discussed in connection with windmill tests. For the purposes of experiment and demonstration this Office has established farms at Cheyenne, Wyo.; Eads, Colo.; and Newcastle, Wyo. The object of the work at these farms is to determine the best methods of securing a water supply, the cost of securing it, the best methods of using water under these conditions, and the probabilities in the way of crop production. At the Cheyenne farm water is pumped by means of windmills, and at Newcastle and Eads by means of gasoline engines. At Cheyenne and Eads the experiments have included also the construction and lining of reservoirs. In each case much difficulty was met in making the reservoirs hold water, and it was necessary to line them. The work so far at the farms has been chiefly preparing the land for irrigation, securing a water supply, and equipping the farms. A statement of the cost of

the windmills used at Cheyenne and the expense of maintenance and operation has been given (p. 392). Similar statements for the Eads and Newcastle farms are not yet available.

Perhaps the largest source of water supply on the plains has not been tested at any of these stations—that is, the storage of storm waters by the construction of reservoirs which will collect the drainage from considerable areas and hold it for use on smaller areas. Considerable areas have been supplied in this way by individuals scattered throughout the plains region. A study of their methods, and the results secured, has been made by F. C. Herrmann, and the results published as a bulletin of this Office.[a] The reservoirs examined by Mr. Herrmann were located in Wyoming, Montana, and South Dakota, and were used partly for stock water, partly for raising winter feed for cattle and sheep, and partly for raising vegetables and fruit. The matter relating to reservoirs which follows is taken from that bulletin.

The most available sites are natural draws which can be dammed so as to hold the run-off from considerable areas. There are two types of such reservoirs, those made directly in the drainage channels and those made outside the drainage channels, to which water is conveyed through ditches. Reservoirs in the drainage channels have the advantage of catching the entire run-off of their drainage areas and of not requiring supply ditches. They have the disadvantage of being more liable to destruction by unusual floods and to filling with silt and of requiring wasteways to take care of surplus water. The reservoirs outside of drainage channels require diversion works in the drainage channels and supply ditches. They are safer than those in the channels, require only small wasteways, and will not fill with silt. They will not, however, get all the run-off from their catchment areas during heavy storms, unless very large supply ditches are made. Where there is a choice of sites, those in which the prevailing wind blows from the dam over the reservoir are better, because the waves will not wash the dams. However, there is not usually any choice in this matter.

Mr. Herrmann estimates from the available data regarding rainfall and run-off in Wyoming that about 18 per cent of the annual rainfall is available for storage. This of course will vary widely with the character and slope of the ground surface, the character of the precipitation—whether in short, heavy storms or in gentle, long-continued rains—and other local conditions. But assuming that the estimate of 18 per cent represents the average, with an annual rainfall of 12 inches, 5.5 acres of drainage area will supply 1 acre-foot of

[a] U. S. Dept. Agr., Office Expt. Stas. Bul. 179.

water; with a 15-inch rainfall 4.5 acres; with an 18-inch rainfall, 3.75 acres; and with a 20-inch rainfall, 3.5 acres.

Mr. Herrmann secured cost data for thirty-one reservoirs built by the Chicago and Northwestern Railway Company for watering stock being driven to its lines for shipment, and for eighteen reservoirs built by private parties for irrigation. These data are presented in the following tables:

Reservoirs constructed by the Chicago and Northwestern Railroad for watering stock.

Name.	When built.	Number.	Dam. Maximum height.	Dam. Top length.	Capacity.	Area.	Average depth.	Original cost. Total.	Original cost. Per acre-foot.	Cost of maintenance. Total.	Cost of maintenance. Annual.
			Feet.	*Feet.*	*Acre-feet.*	*Acres.*	*Ft.*				
West line:											
Casper Creek	1895	25	13.6	689.0	75.3	21.0	3.6	$1,891.00	$25.11	$3,222.52	$358.06
Powder River	1896	4	24.1	200.0	11.5	2.5	4.6	782.00	68.60	6.68	.84
East Woolton	1897	9	16.0	207.0	14.6	3.2	4.6	550.47	37.70	393.21	56.00
Poison Creek	1895	23	15.3	534.5	59.2	13.5	4.3	1,637.80	27.66	444.43	49.00
Forks	1896	8	16.0	218.0	13.8	3.1	4.4	470.25	34.08	206.25	25.00
Tisdale	1897	10	14.0	234.5	15.5	......	.....	520.50	33.58	336.50	48.00
Cut Bank	1901	12	17.5	375.0	18.7	4.7	3.9	1,081.91	57.85	8.40	2.80
Cloud Creek	1903	11	14.6	259.0	18.0	3.8	4.8	1,231.30	68.41	250.00	250.00
Sage Creek	1896	28	14.0	259.0	99.2	17.8	5.6	2,287.00	23.05	....	....
Lusk	1898	1	9.0	150.0	6.6	2.0	3.3	85.97	13.03	....	....
Duck Creek	1900	6	12.5	200.0	12.3	3.0	4.1	473.86	38.84	....	....
Badwater Creek	1901	17	14.0	270.0	31.9	8.5	3.8	813.00	25.49	11.75	4.00
Soldier Creek	1904	11a	17.0	319.0	18.0	3.8	4.7	1,009.15	56.06	....	....
North line:											
Crow Creek	1895	15	10.0	450.0	25.8	5.8	4.5	474.45	18.46	906.43	101.00
Dry Creek	1898	2	16.0	352.0	7.4	3.8	1.9	371.56	50.21	320.49	53.00
Roundout	1895	21	12.0	588.6	46.9	10.4	4.5	568.21	12.12	1,553.72	172.00
Box Elder	1895	22	12.0	403.0	52.7	11.7	4.5	550.00	10.42	1,848.47	205.00
Flying V	1895	27	12.0	448.0	87.5	19.5	4.5	909.90	10.39	2,263.16	251.00
Cheese Factory	1895	24	18.0	600.0	71.6	15.9	4.5	1,346.62	18.83	2,793.19	310.00
Montgomery [a]	1895	20	12.0	338.0	38.4	8.6	4.4	545.26	14.20	776.29	86.00
Short Creek	1895	19	10.0	327.0	34.2	7.6	4.5	393.13	11.53	687.75	76.00
Battle Creek [a]	1895	26	15.0	950.0	85.0	18.9	4.5	712.25	8.40	2,598.71	288.00
East Cottonwood	1896	30	20.0	435.0	187.4	53.6	3.5	1,438.00	7.68	475.43	59.00
Corral Creek	1896	29	14.8	468.0	186.1	53.2	3.5	1,266.00	6.82	745.43	93.00
Bull Creek [a]	1897	16	15.5	392.0	27.0	8.0	3.4	657.75	24.36	1,433.35	204.00
Indian Springs [a]	1895	13	13.2	345.0	19.0	......	.....	407.68	21.57	187.99	21.00
New Indian Spring	1900	7	15.0	230.0	13.2	2.8	4.7	427.00	32.35	627.87	158.00
North Butte Creek	1895	14	......	....	23.9	......	.....	1,126.75	47.10	1,317.49	146.00
New Battle Creek	1902	18	15.3	670.0	32.8	11.5	2.9	1,614.00	49.21	26.15	13.00
New Bull Creek	1903	5	16.0	400.0	12.2	......	.....	719.60	58.99	82.99	83.00
Grouse Creek	1903	3	16.8	240.0	9.3	5.5	1.7	673.36	72.40	....	....

[a] Abandoned.

Private reservoirs on the prairie.

Name.	When built.	Dam.					Outlet.	
		Maximum height.	Top width.	Top length.	Water slope.	Outer slope.	Kind.	Size.
		Feet.	*Feet.*	*Feet.*				*Inches.*
Oliver		8	4	200	1 on 1½	1 on 1½	Wooden box.	8 by 8
Brant	1900	8	8	350	1 on 2	1 on 1	do	
Harris No. 1	1900	12	6	175	1 on 1½	1 on 1½		
Harris No. 2	1904	12	6	500	1 on 3	1 on 1½	Wooden box.	6 by 12
Harris No. 3	1905							
Gray (5)	1905	15–20	10	100–150	1 on 3	1 on 1½	Wooden box.	
Barbour (3)		12	10	100–150	1 on 2	1 on 1½	do	
Kidd	1903	20	12	200	1 on 3	1 on 2	Lap-welded pipe.	7
Warner	1903	16	10	110	1 on 3	1 on 2	do	6
Ryan	1899	8	10	400	1 on 1½	1 on 1½	do	8
McDonald	1905	12	15	500	1 on 4	1 on 2	do	8
Ballard	1904						None	
Hemmingway	1904	16	10	850	1 on 3	1 on 2	Lap-welded pipe.	6
Garvey No. 1	1898	14	10	1,000	1 on 3	1 on 2	do	6
Garvey No. 2	1904	17	10	900	1 on 3	1 on 2	do	10
Sedgewick	1900	14	6	800	1 on 2½	1 on 1½	do	6
Whoop Up	1899	29	10	885	1 on 3	1 on 2	do	8
Edgemont	1896	32	10	1,100	1 on 3	1 on 1½	C. I. pipe	16

Name.	Wasteway.		Capacity.	Area.	Average depth.	Original cost.		Area irrigated.
	Depth.	Width.				Total.	Per acre-foot.	
	Feet.	*Feet.*	*Acre-feet.*	*Acres.*	*Feet.*			*Acres.*
Oliver			10	4	2.5	$200	$20.00	10
Brant	4		60	15	4.0	200	3.33	50
Harris No. 1	Natural.		10	3	3.3	80	8.00	[a] 1⅛
Harris No. 2	4		85	20	4.2	500	5.88	150
Harris No. 3			100	25	4.0	750	7.50	
Gray (5)	Natural.		60	12	5.0	900	15.00	
Barbour (3)			25	7	3.5	250	10.00	20
Kidd	5	40	60	8	7.5	2,000	33.33	35
Warner	4	10	16	2	8.0	400		
Ryan	2	20	35	8	4.4	350	10.00	20
McDonald	Natural.		75	15	5.0	700	9.33	
Ballard	2	15	10			500	50.00	([b])
Hemmingway	2	30	65	12	5.5	1,000	15.00	[c] 60
Garvey No. 1	4	10	435	75	5.8	6,000	4.30	150
Garvey No. 2	8	30	1,000	160	6.3			
Sedgewick	3	25	300	50	6.0	3,000	10.00	400
Whoop Up	4	50	1,300	168	7.7	3,500	2.69	
Edgemont	4	25	1,405	120	11.7			

[a] Also used for domestic purposes.
[b] Used for watering stock.
[c] Does not include 8 small reservoirs.

The average first cost of the railroad reservoirs per acre-foot of capacity is $20, and the annual cost of maintenance $2.57 per acre-foot capacity. The average first cost of the private reservoirs per acre-foot of capacity is $5.58, not including the value of the land, which is very small. The annual cost is not given. Assuming a duty of 2-acre feet per acre, this makes the first cost of a water supply $40 and $11.40 per acre served under the two groups of reservoirs, respectively. This is very much cheaper than the windmill equipment given on page 391.

CROP RETURNS.

The crop returns under irrigation in the semiarid region vary greatly with the crops grown. The crops irrigated by means of the windmill plants reported by Mr. Fuller were principally gardens and fruits. The returns as estimated by the owners and reported by Mr. Fuller averaged as follows: Arkansas Valley in Kansas, $96.36 per acre per year; Platte Valley in Nebraska, $67 per acre per year; and on the plains in eastern Colorado, $65 per acre. The crops irrigated by means of the reservoirs reported on by Mr. Herrmann were principally native hay and alfalfa for the winter feeding of stock, the returns being difficult to segregate. On one ranch the gross returns from 10 acres were estimated at $175, and the net returns, deducting the cost of raising the crop and interest on the cost of the reservoirs, $130, or $13 per acre. On another ranch the 35 acres irrigated gave a net return of $355, or more than $10 per acre. Another ranch on which were irrigated 175 acres of alfalfa and native hay shows net returns of $2,500—more than $14 per acre.

It is apparent from these statements that irrigation in the semiarid region, in connection with dry farming or stock raising, is profitable. No reliable estimate of the total area which can be irrigated in this way can be made, because of the uncertainty as to both underground water and sites for storage, but the possibilities in both pumping and storage are great.

IRRIGATION OF RICE.

Along the Atlantic coast rice has been grown for more than two centuries, and in Louisiana for more than a hundred years. The decadence of the industry along the Atlantic coast and its rapid expansion along the Gulf coast led to the undertaking of an investigation of methods of irrigation in 1901 by this Office. In that season studies were made in both fields, and these have been continued to the present time in Louisiana and Texas, and have been extended to Arkansas, where the growing of rice has reached a considerable extent. Outside of the Atlantic Coast States the water for the irrigation of rice must be pumped, and the investigations have dealt principally with the pumping plants in use and the quantities of water used. The results of these studies are contained in bulletins of this Office,[a] and a report not yet published.

The results of the mechanical and fuel tests of pumping plants are included in the tables giving results of all pump tests (p. 384), and the other results are summarized below, the tables being taken from the reports above mentioned, prepared principally by Prof. W. B. Gregory, of Tulane University, of New Orleans.

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[a] U. S. Dept. Agr., Office Expt. Stas. Buls. 113, 158, pt. 7, 183, 201.

QUANTITIES OF WATER USED.

Measurements of the quantities of water used have been carried on from 1901 to 1908, inclusive, the measurements being of two classes—the quantities of water pumped into the main canals and the quantities of water delivered to individual fields. These measurements are brought together in the following table:

Results of water measurements on rice fields.

No.	Year.	Location.	Depth received from canal.	Rainfall.	Total depth received.	Depth of evaporation.	Net depth absorbed by soil and taken up by rice.	Number of days for measuring evaporation.	Average evaporation per day.
			Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*		*Inch.*
1	1901	Crowley, La.......	16.47	10.04	26.51	14.47	12.04	63	0.230
2	1901	Raywood, Tex...	19.66	9.15	28.81	16.03	12.78	71	.226
3	1902	.....do............	19.71	11.08	30.79	17.45	13.34	91	.190
4	1902	Lake Charles, La.	23.64	7.10	30.74	11.53	19.21	77	.150
5	1903	Estherwood, La..	12.67	19.00	31.67	15.69	15.98	98	.160
6	1903	Eagle Lake, Tex..	7.37	13.78	21.15	9.83	11.32	84	.117
7	1904	Estherwood, La..	5.01	18.52	23.53	14.91	8.62	91	.164
8	1904	Crowley, La.......	5.44	20.54	25.97	13.30	12.68	98	.136
9	1904	Nottowa, Tex....	14.12	19.97	34.09	18.25	15.84	119	.153
10	1905	Estherwood, La..	2.59	30.31	32.90	17.85	15.05	98	.182
11	1905	Welsh, La.........	13.08	29.19	42.27	16.41	25.86	105	.156
12	1905	Lonoke, Ark.....	30.29	19.25	49.54	9.65	39.89	119	.081
13	1906	Crowley, La......	11.30	13.87	25.17	9.39	15.78	105	.089
14	1906	Gueydan, La......	34.81	12.98	47.79	11.21	36.58	112	.100
15	1907	Crowley, La......	19.60	11.57	31.17	11.01	20.16	91	.121
16	1907	Gueydan, La......	9.92	11.45	21.37	9.10	12.27	77	.118
17	1908	Crowley, La......	12.95	21.22	34.17	18.85	15.32	119	.158
		Mean.......	15.21	....	....	....	....	....	....

Results of water measurements on canal systems.

No.	Year.	Location.	Depth received from canal.[a]	Rainfall.	Total depth received.	Name of canal.	Number of days for measuring evaporation.
			Inches.	*Inches.*	*Inches.*		
18	1906	Abbeville, La...........	30.10	18.44	48.54	Abbeville.....	139
19	1906	Gueydan, La............	26.36	12.98	39.34	L. and H......	140
20	1906	Estherwood, La.........	27.67	15.72	43.39	Morris.........	127
21	1906	Lake Charles, La.........	37.06	12.72	49.78	Farmers......	121
22	1907	Abbeville, La...........	27.60	27.81	55.41	Abbeville.....	162
23	1907	Gueydan, La............	35.80	11.45	47.25	L. and H.....	96
24	1907	Estherwood, La.........	31.44	39.89	71.33	Morris.........	176
25	1907	Lake Charles, La........	38.04	19.89	57.93	Farmers......	103
26	1907	Andrews, La.............	20.55	33.99	54.54	Hunter.......	164
27	1907	Beaumont, Tex..........	19.93	19.01	38.94	Neches........	112
28	1908	Lake Charles, La........	....	33.44	....	Farmers......	140
29	1908	Abbeville, La...........	24.60	34.10	58.70	Abbeville.....	....
30	1908	Gueydan, La............	28.30	40.66	68.96	L. and H.....	154
31	1908	Beaumont, Tex..........	19.65	....	....	Neches........	....
32	1908	Andrew, La..............	26.35	31.24	57.59	Hunter.......	188
33	1908	Estherwood, La.........	29.25	....	....	Morris.........	....
		Mean.............	26.04	....	....	....	....

[a] Average depth to which water received by canal would cover land served.

As shown by this table the average quantity pumped per acre irrigated is 26 acre-inches, and the average quantity delivered per acre irrigated is 15 acre-inches or sufficient water to cover the land to a depth of 15 inches.

COST AND PROFITS OF PUMPING WATER FOR IRRIGATION.

In Louisiana and Texas water for the irrigation of rice is supplied principally by canal companies which pump the water from streams and bayous and convey it through large canals to the place of use, taking as pay a part of the crop grown, usually one-fifth. Professor Gregory has computed the cost and returns of a number of typical pumping outfits, as shown in the table which follows.

Plant No. 1 consists of water-tube boilers, compound-condensing engine, and high-grade centrifugal pump.

Plant No. 2 consists of water-tube boilers, compound-condensing engines, and rotary pumps.

Plant No. 3 consists of water-tube boilers, simple-condensing Corliss engines, and centrifugal pumps.

Plant No. 4 is what would ordinarily be termed a "cheap" outfit, consisting of return-tubular boilers, slide-valve, noncondensing engines, and cheap centrifugal pumps.

The lift is taken at 20 feet, the area to be irrigated at 9,000 acres, and the quantity of water pumped at 2 acre-feet per acre. The fuel is oil, at 50 cents per barrel of 42 gallons.

Cost and profits for pumping water for rice irrigation, with an average crop of 8 barrels per acre.

Plant No.	Total investment.	Fixed charges per acre, including canal charges.	Cost of fuel per acre.	Total cost per acre.	Rice at $2.50 per barrel.			
					Amount received per acre.	Profit per acre.	Profit on 9,000 acres.	Per cent profit on investment.
1	$124,000	$2.10	$0.25	$2.35	$4.00	$1.65	$14,850	12.0
2	132,000	2.22	.21	2.43	4.00	1.57	14,120	10.7
3	124,000	2.10	.45	2.55	4.00	1.45	13,050	10.5
4	127,400	2.24	.78	3.01	4.00	.99	8,910	7.0

Plant No.	Rice at $3 per barrel.				
	Amount received per acre.	Profit per acre.	Profit on 9,000 acres.	Per cent profit on investment.	Minimum price for rice, to make plant just pay expenses.
1	$4.80	$2.45	$22,050	17.8	$1.47
2	4.80	2.37	21,330	16.25	1.52
3	4.80	2.25	20,250	16.3	1.59
4	4.80	1.79	16,110	12.6	1.88

COST OF PUMPING WITH INDIVIDUAL PLANTS.

Much good rice land is not under canals, and many farmers who might secure water from a canal have considered it wise to put in their own pumping plants to make themselves independent of the

canal companies. During the season of 1907 a large amount of data relating to these plants in Louisiana and Arkansas was collected for the purpose of supplying to others reliable information as to the cost of pumping and the relative advantages of this means of securing a water supply and purchasing water from a canal company.

The fuels used were wood, coal, and crude oil, the oil being used in Louisiana only. Interest is assumed at 7 per cent and depreciation at 10 per cent, and the quantity of water pumped per acre served is assumed at 15 acre-inches, the average of all measurements in Louisiana and Texas.

Summary of results of tests of well pumping plants.

LOUISIANA.

Plant No.	Lift.	First cost.	Area irrigated.	First cost per acre irrigated.	Fixed charges per acre irrigated.	Fuel cost per acre irrigated.	Attendance per acre irrigated.	Total annual cost per acre irrigated.
	Feet.		*Acres.*					
2	17.50	$2,668	140	$19.06	$3.33	$2.03	$2.00	$7.36
3	23.86	2,200	300	7.33	1.24	2.93	.93	5.10
4	27.00	4,404	230	19.15	3.26	4.25	1.22	8.73
5	33.25	3,300	175	18.86	3.21	1.78	1.60	6.59
6	21.00	2,500	140	17.86	3.04	2.68	2.00	7.72
7	7.81	2,524	165	15.30	2.60	2.34	1.71	6.65
8	6.27	3,500	200	17.50	2.98	2.35	1.40	7.73
Total and average	19.53	21,096	1,350	15.63	2.66	2.56	1.45	6.67

ARKANSAS.

Plant No.	Lift.	First cost.	Area irrigated.	First cost per acre irrigated.	Fixed charges per acre irrigated.	Fuel cost per acre irrigated.	Attendance per acre irrigated.	Total annual cost per acre irrigated.
9	27.60	$1,800	45	$40.00	$6.80	$2.90	$6.22	$15.92
10	35.80	2,100	92	22.82	3.88	2.88	3.04	9.80
11	37.50	3,350	110	30.48	5.18	4.46	2.55	12.19
12	29.60	1,939	72	26.93	4.58	3.13	3.89	11.60
13	51.30	2,963	100	29.63	5.03	2.78	2.80	10.61
14	36.80	3,241	240	13.50	2.30	3.63	1.17	7.10
15	34.20	2,200	115	19.13	3.25	5.60	1.87	10.72
16	32.00	1,600	70	22.86	3.89	5.44	4.00	13.33
17	51.00	2,205	80	27.56	4.69	8.01	3.50	16.20
18	55.00	3,500	55	63.64	10.81	6.01	5.10	21.92
Total and average	39.80	24,898	979	25.43	4.32	4.43	2.86	11.61

The table shows that the average cost of pumping at the well plants tested in Louisiana is $6.67 per acre, while that at the Arkansas plants is $11.61 per acre irrigated. The average lift at the Louisiana plants is approximately 20 feet, and at the Arkansas plants approximately 40 feet, the increase in cost not being quite proportional to the increase in lift. Although the Arkansas rice planters secure their water supply at a slightly smaller cost per acre per foot of lift, yet they must contend against a considerably higher cost of water than that borne by the Louisiana planters, due entirely to the increased lift.

Coming to the comparison between taking water from a canal company in Louisiana and installing and operating a pumping plant large enough for a farm of ordinary size, we will assume an 8-barrel crop and that the average price of rice is $3 per barrel. In case water

is taken from a canal system the charges of the canal company will be $\frac{1}{5} \times 8 \times \$3 = \$4.80$ per acre. With rice selling at $2.50 per barrel, the amount paid the canal company would amount to $4. When the farmer raises a 10-barrel crop, and the price is $3 per barrel, the cost will be $6, while if the price of rice is $2.50, the water for the 10-barrel crop will cost $5. The average cost of pumping per acre in Louisiana, as shown by the table, is $6.67. This is based on the pumping of 1¼ acre-feet per acre. If more water is used, the cost will be approximately $2 additional per acre-foot used. It appears, then, that under ordinary conditions there is a slight financial advantage in securing water from a canal. Under abnormal conditions there are advantages on either side, and it is a matter of balancing these. In years of heavy rainfall and good crops the canal company secures its share of the crop for a minimum of service. Under the same circumstances the owner of a pumping plant saves his fuel charges. His interest is the same and his depreciation is nearly as great as in years when his plant is in full operation. On the basis of the plants shown in the table, the cost, if no pumping is done, will be $2.66 per acre, and the owner would gain the difference between this and the payments to the company. On the other hand, in case of crop failure for any reason, there are no payments to the canal company, while the cost to the pump owner will still be $2.66 per acre in addition to whatever is spent for fuel and attendance. This comes at a time when he has no crop from which to meet it, while the increased payments to the canal company come at a time when he is best able to bear them.

COST AND PROFITS OF RICE GROWING.

The cost of growing rice varies widely, but two statements covering considerable areas are reported by Professor Gregory. One is prepared by the North American Land and Timber Company, of Lake Charles, La., and represents a five-years' average on 5,000 acres. It is as follows:

Cost of growing rice in southwest Texas.

	Per acre.
Plowing land	$2.00
Disking and harrowing	.75
Seeding and rolling and seed	2.50
Looking after water and crop ninety days in summer	1.80
Cutting and shocking	2.00
Thrashing, sacks, and hauling to warehouse	4.00
Cost of loading rough rice on cars, insurance, storage, and warehouse	.75
Cost to the farmer for water	5.50
Interest on mules, farming machinery, and land	4.00
Fertilizer	1.00
Total	24.30

This statement covers the entire cost, as labor was all hired. A farmer often does a large part of his own work and does not include his wages in his estimate of the cost of production. Interest on the investment in land, animals, machinery, and pumping plant, if one is owned and operated, also depreciation, must be included in a statement of total cost of raising rice.

Mr. John C. Chaney, of Beaumont, Tex., has prepared a statement showing the cost of growing rice in southeast Texas. These figures are based on actual experience of five years and on the investment of $37,500 in land and $12,000 in farm equipment, as it is necessary to own 1,500 acres in order to farm 1,000 continuously.

The estimate is based on a 10-sack yield on 1,000 acres of land located on the canal of the Beaumont Irrigating Company in Jefferson County, Tex., farmed by Mr. Chaney for five years.

	Per acre.
Plowing	$1.50
Harrowing	1.00
Planting	.75
Fertilizer	1.00
Seed	2.25
Irrigating and levee repairs	.50
Binding twine	.35
Harvesting and shocking	2.00
Thrashing	2.75
Sacks	1.00
Hauling to warehouse or railroad	1.00
Storage and insurance	.80
Irrigation	6.00
Wear and tear on farm equipment	2.00
Interest on investment in land	3.00
Interest on investment in farm equipment	1.00
Superintendence	1.00
Total	27.90

There are some failures in every branch of agriculture and in every line of business. The personal character of the farmer, his training and experience, and above all his business ability and good judgment, are the factors that determine success or failure. The final result is the product of many factors.

Rice is most successfully raised by the small farmer. This crop responds to careful and thorough methods of culture to such an extent that the statement has been made that the yield per acre varies inversely with the number of acres planted per man. This is another way of saying that the average farmer attempts to plant and water too great an acreage.

Over against the man who has made a failure may be placed the man who has bought land at $15 per acre, installed a well-pumping plant, at a cost of approximately $2,000, and from the proceeds of his first crop raised on 100 to 200 acres has paid for pumping plant, land, and cost of producing the crop.

The average yields of rice per acre in 1907 were about as follows:

	Sacks.
Louisiana	7
Texas	8
Arkansas	9

If the careless farmers are eliminated the yield per acre will be increased by 25 per cent. Along the large canals a great deal of the land is worked by ten-

ants, who do not take the same interest in maintaining the fertility of the soil as do the owners of land. With small farms and good cultivation a yield of 10 sacks per acre may be expected, while in exceptional cases the yield will be as great as 15 to 20 sacks per acre. The average price of rice for the last few years has varied from about $3 to $3.50 per barrel. Where a fine grade of rice, suitable for seed, is raised the price is often $5 to $6 per barrel.

Taking $3 and $3.50 as the selling price of rice per barrel, and for the comparison calling a sack the equivalent of a barrel, and accepting the estimate of total cost of raising rice as $24.30, we have the following results:

Cost and profits of growing rice.

I.	II.	III.		IV.	
Yield per acre in sacks.	Cost per acre to raise.	Returns per acre, at $3 per sack.	Profit or loss per acre.	Returns per acre, at $3.50 per sack.	Profit or loss per acre.
7	$24.30	$21	[a] $3.30	$24.50	[b] $0.20
8	24.30	24	[b] .30	28.00	[b] 3.70
9	24.30	27	[b] 2.70	31.50	[b] 7.20
10	24.30	30	[b] 5.70	35.00	[b] 10.70
11	24.30	33	[b] 8.70	38.50	[b] 14.20
12	24.30	36	[b] 11.70	42.00	[b] 17.70
13	24.30	39	[b] 14.70	45.50	[b] 21.20
14	24.30	42	[b] 17.70	49.00	[b] 24.70
15	24.30	45	[b] 20.70	52.50	[b] 28.20

[a] Loss. [b] Profit.

It must be kept in mind that all labor, interest on investment, and depreciation are included in the estimated cost of raising rice, so that the man with a 7-sack crop is paid for his labor and all interest on land and pumping plant, in case he has one. If he is farming 100 acres and sells his rice at $3 per barrel he has only $20 in excess of these items. If by careful cultivation he can raise the average yield to 10 sacks per acre and sells it at $3.50 per barrel he will have $1,070 in excess of labor, interest, and all costs, while if he sells at $3 per barrel his profits are cut down to $570.

IRRIGATION IN HUMID SECTIONS.

For many years irrigation has been practiced in the humid sections of the United States to a limited extent, especially with truck crops and meadows. The more or less frequent total or partial losses of crops in these sections create a recurring demand for irrigation as a remedy. The practicability of irrigation depends entirely upon the relation between the cost of a water supply and the increase in crop returns due to the use of water. While there is no question that proper irrigation will increase the yields of crops, it may be that destructive droughts will be so infrequent that the losses due to such droughts will be less than the cost of securing a water supply and applying it to the land. To determine this point this Office has carried on experiments in cooperation with the State experiment stations of Missouri, Iowa, Wisconsin, and New Jersey, and with the North Carolina State board of agriculture. None of these experiments has

been continued long enough to give conclusive results, but the tentative conclusion arrived at is that under present conditions irrigation of general farm crops in the humid sections of the United States is not practicable from a financial standpoint. It is, however, profitable with truck and small-fruit crops. The methods of securing a water supply and of applying water are in general much more expensive than those employed in the West, and experiments have been begun to determine the possibility of applying the western methods. No conclusions on this point have yet been reached.

Irrigation is most extensively practiced in the growing of fall, winter, and spring truck crops along the Atlantic coast from Virginia to Florida. The prevailing methods of application are by sprinkling and through underground pipes, both of which are very expensive. If cheaper methods can be made to serve equally well, the saving to the truck growers will be very great.

As more intensive farming is practiced in the East and the acreage value of crops increases, the losses from drought will be more disastrous and more expense for water will be justified. Therefore, it may be expected that the practice of irrigation will gradually spread until a large part of the agricultural lands of the East will be artificially watered.

Expressed in a few words, the object of the irrigation investigations of this Office is to make a broad study of irrigation and all the influences which affect it, to point out how improvements in legislation and practice can be made, and to endeavor to get these improvements into common use. It is believed that much of the improvement in irrigation legislation, in the organization of irrigation enterprises, and in irrigation practice in the last ten years has been due to the work of this Office. The greatest field for future usefulness seems to be in working out methods of checking the large losses of water under present practice and in supplying to new settlers in irrigated regions such practical information as will enable them to avoid the losses incident to learning a new system of farming.

THE ALLUVIAL LANDS OF THE LOWER MISSISSIPPI VALLEY AND THEIR DRAINAGE.

By Arthur E. Morgan, *Supervising Drainage Engineer.*

There is abundant historical basis for belief that the alluvial region of the lower Mississippi Valley will become one of the most productive and opulent areas in the world. In all countries where agriculture has been carried on such lands have been held in high repute, some of the greatest engineering works of ancient times being those designed to control the water of rivers which overflowed their banks and to drain the inundated lands. In Egypt, the fight to protect areas along the lower course of the Nile from excessive overflow has been waged for thousands of years. The ancient kingdom of Babylon greatly increased its wealth by the construction of levees along the Tigris and Euphrates, and by the drainage of the interior lowlands. In the lower Mississippi Valley are evidences of a dense prehistoric population. In some localities along the margin of the alluvial areas mounds (said by archeologists to be the locations of dwellings) are so numerous that over areas of several square miles it is difficult to find a space of 2 acres which does not contain one or more of them. Near the Mississippi are some of the largest mounds in the country, containing pottery which suggests a comparatively advanced state of development.

The Romans, living in a country largely hilly and sterile, added greatly to their national wealth by reclaiming alluvial lands along the coast. One of the richest agricultural regions of China is the plain formerly overflowed by the Kiang River. Here a system of levees more than 25 feet high protects the land from river overflow, and interior drainage completes the reclamation. Many of the richest parts of China are alluvial regions.

Throughout the coastal countries of Europe similar conquests have been made. The largest and most important of such areas in England is the great level, commonly called "the Fens," on the east coast, where an area of half a million acres or more has been reclaimed. This work was begun by the Romans during their occupation of the islands, and the banks which they built to protect the lands from the sea are still interesting features of that now productive country. One of the earliest reports of drainage commissioners in existence is in reference to the reclamation of this great tract, undertaken during the reign of Charles I, and is signed by Oliver Crom-

well. King Charles opposed the plans for reclaiming this great area, and the successful fight of Cromwell for drainage was among his first public services, giving him the popular title, "Lord of the Fens."

The coastal lands of Holland which have been reclaimed are largely alluvial, and are, perhaps, better known to the world at large than any other drained areas, by reason of the magnitude of the works. During the last three hundred years something more than 200,000 acres has been reclaimed in Holland by diking and draining.

EXTENT OF ALLUVIAL LANDS IN THE VALLEY.

The magnitude of drainage undertakings in America as compared with those in Europe would be better appreciated were it known that in the alluvial regions of the lower Mississippi there are several drainage districts, either established or in process of organization, any one of which has an area two to five times greater than the area of all lands reclaimed along the coast of Holland. Altogether in this region there is, perhaps, fifty times as much swamp and overflowed land as has been reclaimed in Holland.

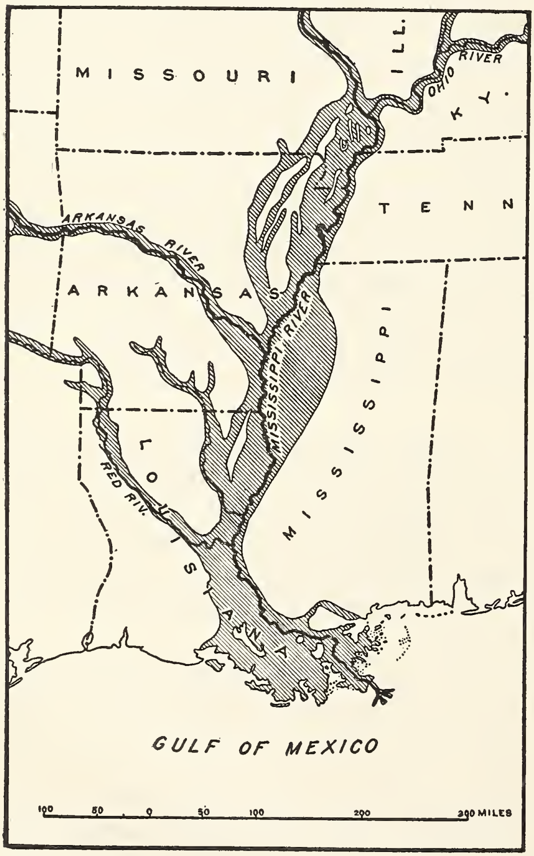

FIG. 3.—Sketch map showing alluvial plain of the lower Mississippi Valley.

The alluvial lands of the lower Mississippi River and its tributaries are those areas which have been built up to their present level by the deposit of sediment carried in the overflow water of these streams. Beginning about 150 miles south of St. Louis and extending to the Gulf, the width of the Mississippi area varies from a few miles to perhaps a hundred miles, while the alluvial deposits of the tributary streams are usually confined within narrower limits.

(Fig. 3.) The southern extremity of this territory has been built up from below sea level, but over most of the area the alluvium has been deposited upon the broad, flat surface of the coastal plain, a formation in some respects similar to the alluvium. The present elevation varies from about 350 feet above sea level at the northern extremity of the region to but a foot or two above mean tide along some parts of the Gulf coast, the slope of the surface toward the south being greater at the north end.

The conditions under which alluvium has been deposited have varied greatly from time to time and in different parts of the region, with the result that there are many types of surface conformation. Nevertheless, the principal features of alluvial topography are so distinctive as easily to be recognized. A brief history of the formation of an alluvial area will give a clearer conception of this topography, as well as a more definite idea of its productive possibilities.

FORMATION OF ALLUVIAL VALLEYS.

A stream coming from the high lands carries in its swift flowing current a large volume of soil matter in suspension. On reaching the flat coastal plain, where there is but little slope to the surface of the ground, the velocity of the water is checked. A channel large enough to carry the water where the fall is great and the current correspondingly swift becomes wholly inadequate in the flat regions. Here the water overflows its banks in all directions, its movement being still slower outside the channel, and the soil particles, hitherto suspended in the current, settle to the ground as alluvium. In this way the surface of the land adjacent to the stream is built up above that of the country more remote. The channel, if ever there was one, becomes filled, and the water spreads out over the surface. Some well-defined hill streams of considerable size, upon reaching the alluvial plain, lose all evidence of streams confined to channels and become extensive swamps. In general, there is a tendency for streams flowing through eroded regions, on entering the coastal plain, gradually to dig channels through the soil of this plain and their own alluvium to the final outlet. There is a tendency also for water which spreads over the surface at the upper end of an alluvial area to concentrate near the outlet into a well-defined channel, which slowly cuts its way up stream to meet the one which is working down from the hills. Most of the large alluvial streams under discussion have in this way cut channels for themselves to their final outlets. Some of these, such as the Arkansas River, show unmistakable signs of their former averseness to confine themselves to definite channels, as evidenced by the lakes, bayous, brakes, abandoned channels, and sandy ridges in the river plains at the points where they debouch

from the hills. Some streams, such as the St. Francis and Black rivers in Missouri and Arkansas, still have lengths of small or indefinite channel between the well-defined stream beds of their upper and lower courses. The Castor River in Missouri and Wabasseca Bayou in Arkansas are streams typical of those which have well-defined channels in the uplands, but entirely lose their identity in the lower plains, where they often form swamps of great extent.

The streams which have channels throughout their entire length continue to overflow their banks in time of high water, unless confined by levees, and this water continues to deposit sediment upon adjacent land. The amount of sediment so deposited varies with the nature of the soil along the course of the rivers, the topography of the upland furnishing the alluvium, and the frequency and character of the storms which cause the floods. On the bottom lands along the Arkansas River the writer has seen an inch of alluvium deposited over the surface of the inundated land as the result of a single overflow of a few weeks' duration. The usual rate of deposit in the Mis-

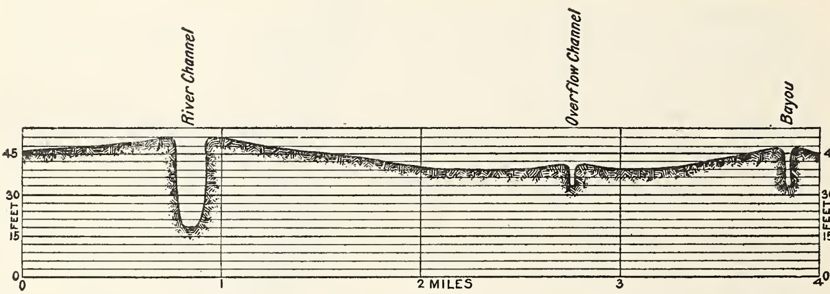

FIG. 4.—Vertical cross section in an alluvial region, illustrating the manner in which alluvial streams build up high banks along their courses.

sissippi Valley, however, is much less. Some branches of the larger streams, which rise in eroded regions, deposit much of their alluvium upon the coastal plain before reaching the main streams. In this way dikes and delta-shaped deposits are built up in various directions across the coastal plain, and these interfere with the general (country) drainage.

The waters which overflow the banks of these streams gather in the lower lands of the interior, and in flowing to their outlet dig for themselves channels called bayous (Pl. XIII). These usually originate either at depressions in the banks of the larger streams, where there are overflows directly from those streams, or in swamp tracts where such overflow waters collect. Along their lower courses these bayous frequently have wide and deep channels, in many cases navigable for river steamers during high water. They also overflow during flood seasons, depositing sediment and building up their banks in a manner similar to that of the larger streams, frequently to a height of 10 feet or more above the surface of the ground 1 to 3

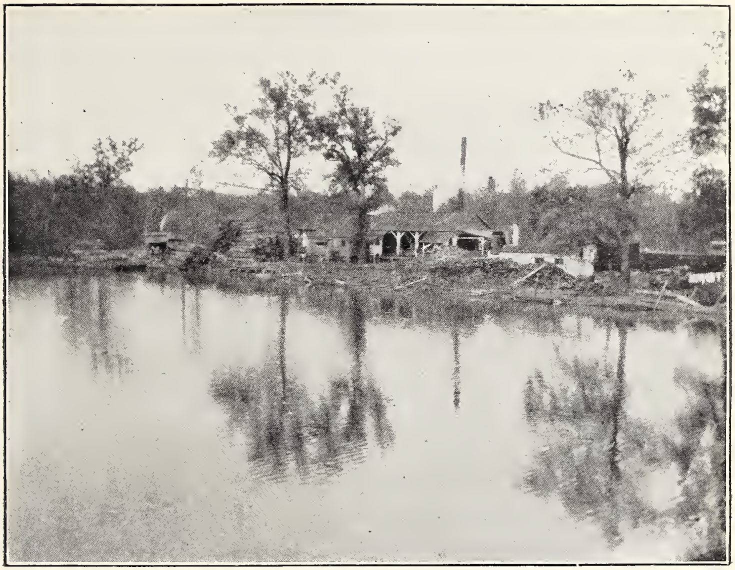

FIG. 1.—BOGGY BAYOU, ARKANSAS.

FIG. 2.—A NATURAL DRAINAGE CHANNEL IN THE ALLUVIAL SANDS OF ARKANSAS.

miles distant (fig. 4). Where the main streams have been confined by levees, so that they do not overflow, the supply of water for adjacent bayous has been largely cut off, and many of them in their present condition afford excellent drainage outlets. The overflow from these bayous gathers in the lowest depressions and finds its way to some outlet, or forms secondary bayous, with banks slightly higher than the surrounding land. These depressions suggest courses for artificial channels for draining the country.

CHARACTERISTICS OF THE SOIL.

There are wide variations in the character of the soil throughout the alluvial regions. The mechanical structure and chemical composition, as well as the fertility, are dependent upon the source of the alluvium. The exceptional fertility of the White River bottoms can, perhaps, be accounted for in this way. Heavy deposits of clay do not seem to produce as fertile soil as lighter deposits, which have a greater variety of soil constituents and a larger proportion of organic matter. The manner in which the alluvium is deposited seems also to modify the character of the soil. Land immediately adjacent to streams, built up from the coarsest and heaviest particles of alluvium, and ridges of sandy land known as gum ridges, have a reputation for great fertility and ease of cultivation, while the soil of some bottom lands, remote from the streams and made up of minute particles of clay which are the last to settle, is commonly regarded as inferior for the production of most crops. It is easily distinguished by a stunted growth of willow, post-oak, and hickory. The alluvium of the Mississippi itself is very fertile—more so, perhaps, than that of many of the branch streams. It is safe to say that no more fertile, well-balanced, and easily tilled soils exist in any part of the humid region of the United States than those of the alluvial lands of the Mississippi Valley.

CHARACTERISTIC VEGETATION.

The native vegetation of alluvial land is, as a rule, a correct index to the character of the soil. Land producing heavy growths of cane may be accepted as very fertile, fairly easily worked, and ordinarily has good natural drainage, except for periods of overflow. Large growths of red gum usually indicate soil of similar character, though the natural drainage may not be so good. Cypress nearly always grows upon land poorly drained or actually submerged, but upon soil of exceptional fertility and excellent tilth when drained and cleared (Pl. XIV, fig. 1). Tupelo gum is usually found with cypress, or on slightly better-drained ground. A heavy growth of numerous varieties of timber on alluvial soil, especially when accompanied by a

rank growth of underbrush, indicates fertility of a high order. A small, stunted growth of post-oak, willow-oak, or hickory, with little or no underbrush, sometimes occurs on alluvial soils at a considerable distance from supply streams, where the deposit consists of the finest clay particles. Such soils have a poor reputation in some parts of the South, being cold, poorly drained, hard to work, and susceptible to drought. When properly drained, they are found to be suited to rice and cotton, but while experiments may prove their suitability for other crops, at present they are probably the least valuable of all Mississippi alluvial lands.

In the lower Mississippi Valley the value of the cotton crop exceeds the combined value of all others. Corn is of next importance, followed by rice, oats, alfalfa, and numerous other crops, while sugar cane is a staple in the extreme South. The yield of cotton on alluvial soils is greater than anywhere else in the South. Where alfalfa has been raised on well-drained alluvial land it produces exceptionally well and promises to be one of the most profitable crops of the region. Corn does not usually yield as abundantly as in the corn belt farther north, though this may be due to faulty methods of cultivation, for both in the extreme northern and in the extreme southern part of the alluvial region yields of 50 to 80 bushels to the acre are secured by men who have become proficient in corn growing (Pl. XIV, fig. 2). Rice yields from 30 to 100 bushels to the acre on land having a sufficiently impervious subsoil to retain the water used for irrigating. The greatest development of rice culture, however, is on the coastal plain soils adjoining the alluvial lands.

Before the construction of levees nearly all streams in the alluvial regions were subject to frequent overflows, which interfered greatly with the development of the region. During the last fifty years there has been constant activity and progress in levee construction, the work being done by districts organized under State laws, and with the assistance of the National Government, until at the present time there is an efficient system extending almost the entire distance from near the south line of Missouri to the Gulf. With the perfection of this system and the great development of levees on the branch streams, the returns from farming operations are becoming much more certain, resulting in a corresponding increase in the value of land. At present the larger part of the land which can be cultivated without drainage is in use, and in many parts of the region efforts are made to farm soils which are very poorly drained.

It may be said that the future agricultural development of the alluvial region is dependent, first of all, upon thorough drainage and protection from overflow. While in many places small areas carefully cultivated are wonderfully productive, the development of the lower Mississippi Valley as a whole can hardly be said to have com-

FIG. 1.—A BAYOU OBSTRUCTED BY TREES AND FALLEN LOGS.

FIG. 2.—CORN UPON RECLAIMED LOWLANDS.

menced. Probably not more than a fifth of the land is in cultivation, and much of this is inefficiently managed. There are but few improved highways, and the condition of railway roadbeds is quite unsatisfactory. Even the larger part of the improved areas is at times too wet for proper cultivation. Moreover, health conditions will not be satisfactory until the surface waters which produce mosquitoes and malaria are removed by drainage.

COMPREHENSIVE DRAINAGE WORKS REQUIRED.

While the work of leveeing the streams has been of first importance, and has progressed to a point where the Mississippi and its tributaries are effectively controlled, very little efficient drainage work has been done except in the extreme north and the extreme south of the alluvial region. Very recently great interest has been taken in drainage over the whole territory, many ditches and canals have been laid out, and some of them constructed. Their value has been largely reduced by reason of imperfect plans, if they can be said to have been planned at all. During the next few years perhaps fifty or a hundred million dollars will be spent for the drainage of this alluvial land, and it is of prime importance that the work shall be done in an efficient manner.

Drainage work required for the reclamation of this region naturally falls into two classes: (1) The systems of main drainage outlets, and (2) the detail drainage of individual farms or small areas. The larger drainage units vary greatly in size, being in each instance those which can be reclaimed without directly affecting or being affected by other areas. Sometimes, in the case of small streams coming out of the hills, or of bayous which, farther on, have efficient channels, main districts may contain not more than 10,000 to 50,000 acres. In other cases an entire river basin should be treated as one drainage problem, in which a single district may contain 1,000,000 to 2,000,000 acres of land. The largest of the drainage districts heretofore organized contains more than a million acres.

Considering, first, the larger or main drainage projects, we note that outlets are in many instances very difficult to secure. The prevailing slope of the country is usually parallel to the streams, and the surface of the land to be drained frequently lies below their high-water surface. The main drains must often be extended for long distances parallel to these streams before suitable discharging points can be secured. The slope of the surface is slight, varying from a few inches to 1 foot to the mile. In many instances boundary lines between drainage areas are poorly defined, so that during flood season the entire surface between two or more widely separated channels may be covered with water, which flows toward the stream happening at that time to be at the lower stage.

The success of drainage on a large scale in the alluvial regions depends to a considerable extent upon the wisdom and judgment used in outlining these systems of main drains. If their construction is wisely planned and efficiently carried out, the history of further drainage of the fertile lands of this region will be one of orderly development and economical improvement. On the other hand, if the organization of the main drainage districts is carried out in a haphazard, injudicious, and careless manner, the further drainage of the territory will be attended by confusion, duplication of cost, conflict of plans, and limited efficiency. It is a conservative statement that the key to the drainage of the southern Mississippi Valley, both of the alluvial lands and of the coastal plain adjacent, is the proper planning and construction of the main drainage outlets.

The first step in this work is to secure political organization. Most of the States bordering on the lower Mississippi have more or less efficient drainage laws, and through them or through special acts of legislatures, the cooperation of landowners under legal regulations and equitable adjustment of costs can be secured. In organizing large drainage districts it is essential that the boundaries be carefully determined with the assistance of proficient engineers. Otherwise, conflict with the plans of other districts, heretofore or hereafter organized, or the exclusion of territory which ought to be included is almost sure to occur.

It is customary for the drainage laws of some Northern States to specify, in somewhat minute detail, the surveying and engineering methods which shall be employed in planning and constructing works. In the large districts of the alluvial lands of the South, however, such difficult engineering questions must be met that there is ample opportunity for the exercise of ingenuity, skill, and the ability for original investigation in their design. It is therefore desirable that laws for this region give the engineer sufficient freedom for the use of these qualities.

Connected with the political organization of the district is the survey and the preparation of the plans. The survey for a large district consists essentially of two parts: (1) The collection of data upon which to base plans for the work, and (2) the later location of the work on the ground. Ignoring the necessity for a survey to collect data, as well as a lack of definite ideas as to what is the object of a survey for drainage purposes, has resulted in poorly devised plans and the waste of large amounts of money in both survey and construction. Where a large district is involved, the survey for securing data should be completed, and the results platted and otherwise made available, before location is attempted. While the detailed features of such a survey must be determined by the peculiarities of each individual case, they may be outlined in a general way.

REQUIREMENTS OF SURVEYS.

First of all, the topographic features of a district must be ascertained, in so far as they may affect plans for drainage. The surface slopes should be determined either by locating contour lines or by running lines of levels across the district at suitable intervals. Locations of all important streams, bayous, lakes, and depressions should be made, and cross sections and other measurements be taken to determine their capacity and usefulness as drainage channels. The character of the soil as it would affect excavation, the size and kind of the timber, and other similar information should be secured and carefully noted.

When the survey for securing information is completed and the data platted or otherwise made available, the general features of the plan may be determined, with approximate locations on the map for drainage channels. The exact location on the ground can then be made intelligently and quickly. In the handling of large drainage problems desired results can not be secured economically without a full knowledge of the physical conditions. Each situation must be worked out as an original problem. In many cases there are opportunities to effect substantial economies by providing flood gates, dikes, levees, diversion channels, and other engineering structures.

The factors which must be considered in preparing plans include the rainfall, the slope of the surface, the character of the soil, the run-off, and the capacity of present channels. Methods of construction must be determined, and the work planned with reference to the type of machine most suitable. Estimates of cost must be made, and assessments to pay the cost levied against the land benefited.

The primary aim in constructing large drainage outlets is to relieve the tributary areas from overflow water and to provide outlets for lateral drainage. The secondary objects are to complete the drainage of certain areas near the outlet channels, to improve health conditions by removing surface water and the resulting malaria, to better highways and railroad grades, and possibly to secure transportation for the products of the country through the arterial drainage channels.

THE DRAINAGE OF SMALL AREAS.

After main outlet drains have been constructed there still remains the more complete improvement to be effected, by the organization of small districts or the drainage of individual holdings. The smaller districts may be drained either under the same legal proceedings and at the same time that the main outlets are constructed, which seems the more desirable method in most instances, or districts to secure the needed improvement may later be formed under the State laws.

Generally all land included in such a district which is high and dry enough to be farmed is under the usual state of cultivation. Such land is commonly found on the banks of alluvial streams and of the larger bayous, from which the surface falls away perceptibly toward the interior of the basins lying between the main stream channels. Toward the center of these basins the slope becomes less, and the land is wetter, often being overflowed during the entire spring and early summer; so the farther the land is from bayous and other streams with high banks, the smaller is the proportion in cultivation. Gradually landowners encroach upon the swamp margins with their clearings, although on the lower cultivated lands many crops are lost for want of drainage.

The surveys for these smaller districts should in the main follow the same procedure as for the larger areas, sufficient data being secured to warrant the preparation of general plans before a location of drains on the ground is attempted. As such a survey has for its object the complete drainage of the territory, it should be made more in detail than a survey for locating main outlets. The completed ditches should be capable of removing all surface water which may reach the district by rain, seepage, or overflow soon enough to prevent damage to growing crops; and they should also furnish outlets for farm drains, and, in some instances, for tile drainage. It is probable that in the loose, sandy soils of some localities tile drainage will never be needed, while in the heavier clay soils it must be provided before thorough drainage is secured. The depths, dimensions, and shapes of these ditches must be decided with reference to local conditions. As a rule the main drains of the smaller districts, which furnish outlets for 2,000 to 50,000 acres, should be not less than 5, and preferably 8 to 12, feet deep. The side slopes may be steeper in clay than in sandy soils. The widths must be determined by a knowledge of the rainfall, slope of the surface, prospect for efficient maintenance, and other factors. The efficient drainage engineer carefully considers all these conditions, applying his judgment and his knowledge of hydraulics to each case.

CONSTRUCTION OF DRAINS AND RESULTS.

The excavation of all but the smallest ditches is usually accomplished by the floating steam dredge, although there are practical excavating machines of other types. The perfection of dredging machinery in recent years is particularly encouraging to those who have faith in the future of unimproved alluvial lands. The work which in olden times took months to perform can now be accomplished in as many weeks. Wide and deep channels which were once constructed with great difficulty can now be excavated as conveniently

as small ones were under the old methods. In this respect we occupy a place far in advance of the generations which constructed the Roman banks in Britain, the ditches and dikes for the reclamation of Haarlem Lake in Holland, and the English fens. Never could lands be reclaimed so quickly and easily as in the age in which we live—an age of perfected mechanical appliances for controlling the forces of nature and leading them into useful channels.

In addition to the construction of channels in the smaller drainage districts, a large amount of work is required in the detail drainage of farms. Surface ditches are constructed to carry rain water quickly to the nearest drains, or lines of tile are laid to secure the same result.

As the result of the detail drainage of overflowed and wet areas, surface water is removed quickly after the early spring and summer rains, and cultivation is begun at an earlier date than would otherwise be possible. With the advent of the boll weevil this feature of the improvement becomes a very important consideration, even on land which was formerly farmed with profit. Areas which were too wet for cultivation before drainage, in many instances being entirely submerged for the greater part of the year, become valuable farm land, producing as well as the best of the high land. Highways formerly impassable for several months each year remain in good condition; and railroad grades become more stable and require less work for maintenance. Frequently lands which sell for $2 to $10 an acre before drainage, after being reclaimed are worth from $20 to $100. Finally, health conditions are very greatly improved through the removal of the breeding places for mosquitoes.

In the States of the lower Mississippi Valley are 10,000,000 to 15,000,000 acres of land awaiting drainage. The investigations of recent years have established the feasibility of this work, the State legislatures are providing for the necessary legal procedure, and a great public interest is awakened in the prospect for reclamation. The outlook is that during the next few years a vast area of exceedingly fertile land will be added to our agricultural domain, that malaria in the alluvial region will pass away, as it has passed in some of the more northern States where it was once prevalent, and that a prosperous rural people will occupy the entire alluvial lands of the lower Mississippi Valley.

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